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**DISRUPTING HOUSING DEVELOPMENT BY PLATFORM STRATEGY -
A SYSTEM DYNAMICS CASE STUDY**

Examiners: Professor Kirsimarja Blomqvist
Post-doctoral researcher Pontus Huotari

ABSTRACT

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Keywords: digital platform, multi-sided platform, platform strategy, systems thinking, system dynamics, simulation, housing development

Construction is a big, global industry with reduced productivity. Recently, digitalization has reshaped many businesses and even industries. Notably, digital platforms have disrupted current business models and changed the dynamics of value creation. In this research, platform thinking was adapted to the context of construction, more closely the construction of apartment buildings and housing development. The research was a case study commissioned by a Finnish construction company. The objective of the research was to develop and evaluate a platform strategy for the housing development business.

Digital platforms are complex and dynamic structures by nature. To understand network effects and other crucial aspects of the platform, systems approach was used. Platform strategy was developed both with qualitative methods and computational modeling using system dynamics methodology. Based on modeling and simulations, essential environmental and strategic parameters were defined and optimized.

As a result, policy recommendations were given for strategic parameters in different environmental conditions. Also, the analysis emphasized the importance of ecosystem innovation, i.e., the innovation of third parties. Furthermore, insights for different platform maturity stages were given based on literature, research data, and modeling.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
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Tietojohtaminen ja johtajuus

Taneli Heikkilä

Disrupting housing development by platform strategy - A system dynamics case study

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Tarkastajat: Professori Kirsimarja Blomqvist, Tutkijatohtori Pontus Huotari, Ilmiörakentaja Tero Vanhanen (ohjaaja tilaajayrityksestä)

Avainsanat: digitaalinen alusta, monisivuinen alusta, alustastrategia, systeemiajattelu, systeemidynamiikka, simulointi, asuinrakentaminen, hankekehitys

Rakentaminen on suuri, kansainvälinen teollisuudenala, jonka tuottavuus on heikko. Viime aikoina digitalisaatio on muokannut pysyvästi monia yrityksiä ja jopa toimialoja. Erityisesti digitaalinen alustatalous on disruptoinut nykyisiä liiketoimintamalleja ja muuttanut arvonluonnin dynamiikkaa. Tässä tutkimuksessa asuntorakentamista ja hankekehitystä tarkasteltiin alustaliiketoiminnan näkökulmasta. Tutkimuksen tavoitteena oli kehittää ja arvioida alustastrategiaa asuntorakentamiselle. Työ oli suomalaisen rakennusyrityksen tilaama tapaustutkimus.

Digitaaliset alustat ovat luonteeltaan kompleksisia ja dynaamisia rakenteita. Verkostovaikutusten ja muiden keskeisten näkökohtien ymmärtämiseksi tutkimuksessa käytettiin systeemistä lähestymistapaa. Tarkasteltavana olevaa alustaliiketoimintaa kehitettiin sekä laadullisilla menetelmillä että laskennallisella mallinnuksella systeemidynamiikan metodologiaa käyttämällä. Mallinnuksen ja simulaatioiden perusteella määriteltiin olennaiset ympäristömuuttujat ja strategiset muuttujat sekä niiden optimitasot.

Tutkimuksen tuloksena strategisille parametreille annettiin suosituksia erilaisissa toimintaolosuhteissa. Tuloksissa korostui myös ekosysteemi-innovaatioiden, ts. kolmansien osapuolten innovaatioiden merkitys. Alustan kehittymisen eri vaiheisiin annettiin suosituksia kirjallisuuden, tutkimusaineiston ja mallintamisen pohjalta.

PREFACE

I have been loving board games for over a decade. However, it’s not the winning that has attracted me. Instead, it has been fascinating to try to figure out the underlying dynamics of the game. I could easily discuss hours my favorite board games and strategies for them (Power Grid and Agricola, to name a few) even without playing at all.

With this thesis, I have realized that what I’ve been doing with board games is thinking systems. This thesis has been an unforgettable journey to the real-life game of platform business and housing development. What separates this topic from board games, is that there’s more strategy literature available (just google *platform strategy*).

I kindly want to acknowledge everyone who has helped me during the studies and thesis. First of all, thanks to Fira and all the wonderful professionals for sharing this real-life business case with me and offering all the help I needed. I would like to give a special thanks to Tero for all the energetic and fruitful discussions during the process. Secondly, thanks to Kirsimarja and Pontus for encouraging and supporting the academic side. Also, thanks to Sampsa Ruutu for helpful discussions about system dynamics and my mother for meaningful conversations on life and studies. Finally, I thank Irene and the boys: you made this possible.

Järvenpää, 28.2.2020

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1. INTRODUCTION

1.1. Background

Construction is one of the biggest industries in the world, with 13 % of the world's GDP. However, the productivity of construction is far behind other industries: annual productivity has been only 1 % over the past twenty years compared to 3.6 % of annual growth in manufacturing and 2.8 % annual growth in the world economy. (McKinsey & Company 2017, 1.) On the other hand, that is not surprising: there are many explanatory features in the construction industry. Site-specific action, complex processes, and countless different stakeholders, to name a few, all decrease productivity.

Digitalization has reshaped many businesses and even industries. More and more business is changing from physical to digital business models. Weill and Woerner (2015, 72) describe the change from physical "place" to digital "space". The main components of new digital business models are content, experience, and platform (Ibid., 30). However, the construction industry seems to be founded mainly on "the old world".

Amongst all opportunities that digitalization offers, especially the platform economy has gained rising interest. These digital platforms reshape the value creation by connecting different market sides. The platform that works as a mediator between different market sides is called a multi-sided platform (MSP). Hagiu and Wright (Hagiu, Wright 2015) have defined two fundamental features of MSP: (1) it enables direct interaction between two or more distinct sides and (2) each side is affiliated with the platform.

There are many typologies for platforms. One standard definition is to divide the platforms for two types based on their primary function: transaction platform and innovation platform. Typically, the platforms work as a transaction platform, wh(Hagiu, Wright 2015)ere the value is captured from different market side interactions. In turn, innovation platforms are based on platform value-adding through third-party innovation (Cusumano, Yoffie et al. 2019, 66). Enabling this ecosystem innovation aspect is a powerful strategic tool in the competition of platform leadership (Hilbolling 2019, 3). Both of the types are multi-sided platform by definition since they are at least two market sides involved in a platform

Even though there is much interest and also well working multi-sided business models (such as Airbnb, Uber, Facebook), there are no big platforms in the housing industry. Minor start-ups occur, but they lack the leader position and vast user amount. The examples of Finland show that, also inside the construction industry, there are more transaction than innovation platforms. In the construction industry, there is a massive demand for more open and straightforward processes. Also, the rise of individuality and uniqueness, as well as ever-rising apartment prices, challenge today’s status quo.

In this research, platform thinking is adapted to the construction industry, more precisely to housing development and apartment building. The research is a case study commissioned by a Finnish construction company. The company has a strong emphasis on digitalization and platform thinking, and it has been developing a platform strategy for the housing development business. The idea of a platform is to connect the apartment seekers (new housing) with the ones that control the land property. The objective of the research is to develop and evaluate a platform strategy for managing this two-sided market.

How to adopt this relatively new platform discipline to the construction context? Since the world is getting more and more integrated and complex, there is a need for understanding this networked wholeness. Systems thinking is a paradigm focused on systemic phenomena and especially so-called complex systems. Complexity in a system means that the dynamic of the system is not based on linear cause and effect equations but has non-linear patterns and self-organization (Chowdhury 2019, 10). One simplified example of a complex system is a bird flock. The flock finds its’ way without any centralized control, just with self-organization. (Ibid., 15).

Systems approach has both qualitative and quantitative tools. Qualitative systems thinking is focused on understanding the system at a higher level: what are the boundaries of the system, what are the variables and central feedback loops in a system? The quantitative systems approach takes one step further and models the system with exact mathematical equations. With quantitative modeling, it is possible to analyze how does the system functions under different circumstances. These two aspects are combined in a discipline named system dynamics (Sterman 2000).

To thoroughly understand all the essential aspects of platform business, system dynamics is used as a discipline for the case study. Platform strategy is developed both with qualitative methods and computational modeling. Based on modeling and simulations, essential environmental and strategic parameters are defined and optimized. As a result, policy recommendations are given. Also, the importance of the innovation platform aspect, as well as insight for different platform maturity, stages are explored.

1.2. Research questions and limitations

The objective of the research is to develop further and evaluate the platform strategy for housing development initially invented in a commissioned company. The business model under development is named in this research as *a housing platform*. Because of that, the viewpoint of this research is strongly a single firm's – the owner of the platform. Therefore, the focus is on single level decisions and key performance indicators that matter, especially financial success. The broader questions of the platform economy and – for instance - competition between platforms are passed, and the research concentrates on the dynamics of a single platform.

The main interest lies in the question, how to disrupt the conventional housing development process with platform strategy. What kind of strategic decisions are to be made, and how is the operational environment influencing these decisions? The platform case is also considered through concepts of transaction and innovation platform and their implications for strategy. The main research question is:

How to reshape the housing development with platform strategy?

The main question is vast, and obviously, it cannot be answered exhaustively. The focus is on quite a high phenomenon level, and the details such as how the platform should be done at a practical level are not included. However, the most critical aspects of future development are listed in the conclusion chapter.

The main question is divided into several sub-questions in order to answer it. There are both theory-related and empiric-related questions depending on the source of the answer. The questions related to the theory are as follows:

RQ1: What are digital platforms and their key strategic features?
RQ2: What is system dynamics and how it is used?
RQ3: How has system dynamics been used in platform and business development context?

The other set of questions is related to the empirical part of the research. The answers to the empirical questions are based on systemic development and evaluation of the housing platform. This systemic analysis includes both qualitative and quantitative methods. Qualitative analysis is needed for defining the variables, and the quantitative approach reveals the effects and optimal levels of changing variables. These sub-questions are:

RQ4: How does the operational environment influence to platform success?
RQ5: What are the most critical strategic decisions needed for platform success?
RQ6: What is the importance of ecosystem innovation to platform success?

In Table 1, the sub-research questions are shown with the main concepts and the source of the answer. The central concepts are defined in chapter 1.4.

Research question	**Concepts**	**Material**
RQ1: What are digital platforms and their key strategic features?	+ digital platform + multi-sided platform + platform strategy + transaction platform + innovation platform	+ theory (literature)
RQ2: What is system dynamics and how it is used?	+ systems thinking + system dynamics	+ theory (literature)

RQ3: How has system dynamics been used in platform and business development context?	+ network effects + feedback loop + business model + dynamic business model	+ theory (literature)
RQ4: How does the operational environment influence to platform success?	+ model boundary + sector map + causal loop diagram + feedback loop + variable	+ empirical part (modeling and simulation, gathered data)
RQ5: What are the most critical strategic decisions needed for platform success?	(same as above)	+ empirical part (modeling and simulation, gathered data)
RQ6: What is the importance of ecosystem innovation to platform success?	(same as above)	+ empirical part (modeling and simulation, gathered data)

Table 1. Research questions, concepts and material.

The questions above have a static, cross-sectional viewpoint to the platform business model. Even though there are no questions from a longitudinal perspective, this topic was widely discussed during the research process. Since there is interview data about platform development, the maturity stages of a platform are also briefly dealt with in the discussion.

1.3. Theoretical framework

The thesis positions itself under the concept of the platform economy and digital platforms. These are broad terms covering phenomena from macro to micro levels. In this research, digital platforms are considered in a single firm context. Because of the dynamic and complex nature of platforms, system dynamics is chosen as a tool for analyzing the phenomenon. The goal of the research is to develop and evaluate the platform business model from the viewpoint of the platform owner. Therefore, system dynamics modeling is used to determine the platform strategy for the business under consideration. The research is executed in the context of construction and closer housing development. Figure 1 explains the research's main concepts and their relations.

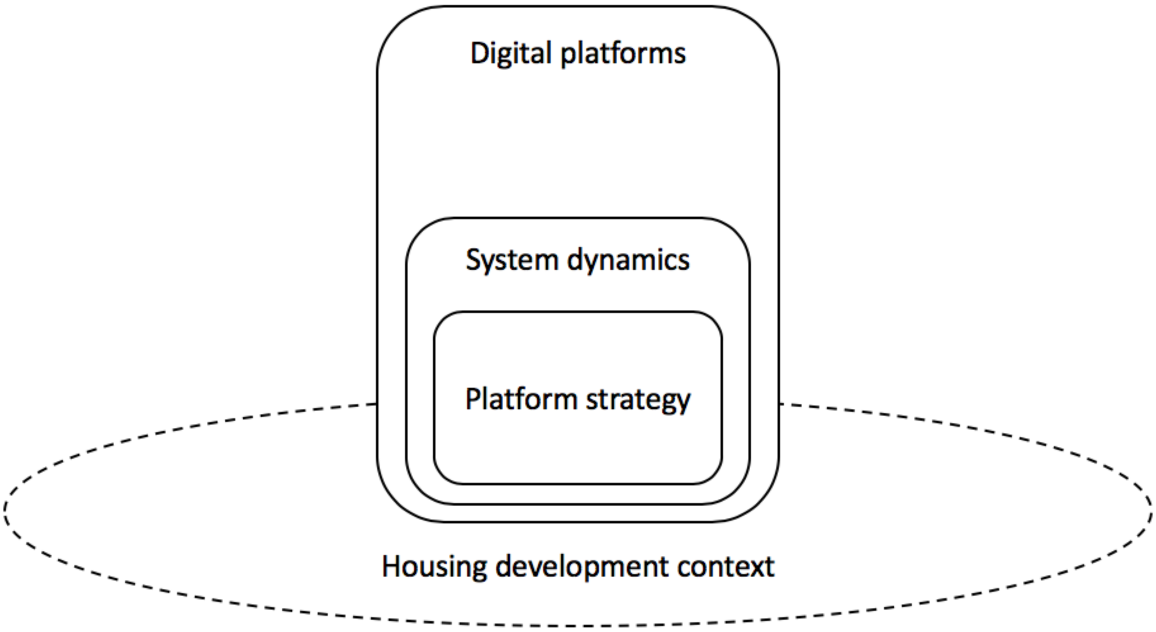

Figure 1. The theoretical framework of the research.

The methodology used in research is based on system dynamics. Compared to natural and social sciences, where the goal is to describe and theorize, the modeling and simulation-based research method is strongly problem-based and solution-focused. Where natural science is searching for truth, system dynamics seeks a solution.

1.4. Definitions and delimitations

The main concepts are defined in Table 2. The definitions explain the meaning of the terms and thus delimit the research.

Digital platform	"A set of digital resources – including services and content – that enable value-creating interactions between external producers and consumers" (Constantinides, Henfridsson et al. 2018, 1).
Multi-sided Platform (MSP)	"Multi-sided platforms enable direct interactions between two or more distinct sides. Each side is affiliated with the platform."

	(Hagiu, Wright 2015, 163). In this research, digital platforms are seen as multi-sided platforms.
Platform strategy	“an approach to entering a market which revolves around the task of allowing platform participants to benefit from the presence of others” (Church 2017)
Transaction platform	Platform type, where the value is created by facilitating the buying and selling of goods and services (Cusumano, Yoffie et al. 2019).
Innovation platform	Platform type, where the value is created by facilitating the development of new complementary products and services built by third parties (Cusumano, Yoffie et al. 2019). In this research, the innovation platform is seen in the close relationship of the platform ecosystem, where platform complementors are adding value to the platform (Jacobides, Cennamo et al. 2018).
Hybrid platform	A platform that combines both transaction and innovation platform features (Cusumano, Yoffie et al. 2019)
Network effect	“The impact that the number of users of a platform has on the value created for each user” (Parker, Van Alstyne et al. 2016, 17). Network effects can be categorized as the same-side and cross-side effects with positive and negative impacts (Ibid., 29).
Systems thinking	“Systems thinking is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired effects. These skills work together as a system.” (Arnold, Wade 2015, 675)
System dynamics (SD)	“System dynamics a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations.” (Sterman 2000, vii)

Housing development	“a group of individual dwellings or apartment houses typically of similar design that are usually built and sold or leased by one management” (Merriam-Webster)
Housing platform	The term is given for a platform developed in this research.

Table 2. Definitions of relevant terms.

1.5. The structure of the thesis

In the first chapter, the research background and problem are presented. The theoretical framework and term definitions are also briefly explained. Also, the structure of the thesis is shown. In chapter 2, the theoretical framework is presented. This chapter has three sub-chapters, and each of these answers to one research question (RQ1, RQ2, and RQ3). Chapter 3 explains the research methodology and conduction of the research. In addition, system dynamics modeling process is explained. In chapter 4, the results of the systemic analysis are presented. This chapter answers to research questions RQ4, RQ5 and RQ6. Finally, in chapter 5, the answer to the main question is given. At last, a brief summary recaps the research in chapter 6. The structure of the thesis is presented in Table 3.

1. Introduction	Introducing the research problem (main RQ + sub-questions)		
2. Theoretical part	Digital platforms **RQ1**	System dynamics **RQ2**	SD and platform development **RQ3**
3. Methodology and model description	Research conduction, modeling process and model settings		
4. Results	The results of the modeling **RQ4, RQ5, RQ6**		
5. Conclusions	Guidelines for housing platform (answer to **main RQ**)		
6. Summary	Recap of the research		

Table 3. The structure of the thesis and research questions.

2. SYSTEMIC VIEW FOR PLATFORM BUSINESS DEVELOPMENT

In this chapter, the theoretical framework is presented. Firstly, the digital platform and the key components of platform business are explained, and after that systems thinking and system dynamics are presented. In the last subchapter, these two themes are combined: how to develop platform strategy through systems thinking?

2.1. An overview of digital platforms

At the moment, many of the most valued companies are platform businesses. Struggling with these newcomers, the big old companies are trying to *platformize* themselves (Constantinides, Henfridsson et al. 2018, 1). Especially, the data-driven digital platforms, together with Internet-of-Things, are changing our everyday life (de Reuver, Sørensen et al. 2018, 133). Constantinides et al. (2018, 1) define the digital platform *"as a set of digital resources—including services and content—that enable value-creating interactions between external producers and consumers"*.

Platforms have been studied for a long time from the viewpoints of economics and management (de Reuver, Sørensen et al. 2018, 124). The focus of the economics view is typically strongly in pricing strategies and financial dynamics (Ibid., 126). As an economic construct, the platform that mediates different user groups is called a *multi-sided platform* (Hagiu 2014, Hagiu, Wright 2015). Hagiu (2014, 5) defines two key characteristics of the multi-sided platform, also *MSP*: "Each group of participants ("side") is customers of MSP in some meaningful way, and the MSP enables direct interaction between the sides." Hagiu distinguishes MSP from the other two other business types. A *Product platform* does not fulfill the definition of MSP since the ultimate customer is not a customer of the platform. *Resellers* violate the requirement of direct interaction between sides and thus differs fundamentally from MSP (Ibid., 5). The three business types are presented in Figure 2.

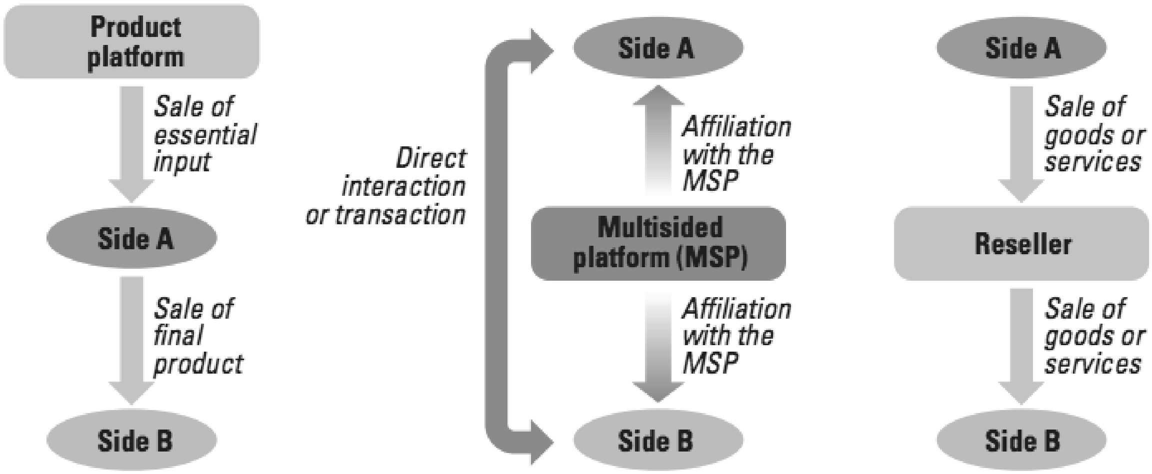

Figure 2. Multi-sided platform compared to other business types (Hagiu 2014, 5).

In reality, there are shades of grey in being MSP or not. Organizations can adjust their relationship and distance to the multi-sided economic model, which affects a lot to the economic dynamics of a business (Hagiu, Wright 2015, 162) and revenue sharing (Hagiu 2018, 592). In successful multi-sided platforms, there are typically two to three sides. LinkedIn, for instance, is a three-sided platform: it connects individual users, recruiters, and advertisers (Hagiu 2014).

Besides from the viewpoint of economic or management, digital platforms can also be considered from the informational systems science. Instead of pricing and financing, the focus is on the dynamics of the technological side. Digital characteristics - such as homogenization of data and reprogrammability - can lead to diffused platform ownership and new meanings of manufactured products. (de Reuver, Sørensen et al. 2018, 126.)

Even though the vast popularity and even hype of platforms during the last years, there are also drawbacks. When the current value chains are disrupted by platform strategy, not all can be the winners. One example of this is a platform business of food delivery and the status of food messengers (Teittinen 2020). On the positive side, these firms have given a chance to get employed. On the other hand, the terms for the employee are often unprofitable or unfair. Also, there are concerns about data privacy and lack of self-regulatory (Cusumano, Yoffie et al. 2019, 207).

2.1.1. Platforms as ecosystems

When considering multi-sided digital platforms, it is difficult to avoid the concept of the ecosystem. Jacobides et al. (2018, 2264) suggest the following description: "*An ecosystem is a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled.*" In the platform context, the ecosystem aspect means, that besides of the platform sponsor, there are also complementors who make the platform more valuable to consumers (Ibid., 2258).

There are three types of complementarity in platforms (Jacobides, Cennamo et al. 2018, 2266). *Unique* complementary means that the two complementarians need each other; one does not function without another. *Supermodular* complementarity implies that besides, it is inevitable to use the two complementarians together, they are making another more valuable. An example of supermodularity is Android open-source software, which offers supermodularity both in production and consumption. Complementarity can also be *generic*: while there is a link between two complementarians, the link is so generic that there are no such concerns for governance or risks of misappropriation. An example of this generic complementarity is cars and tires, or computer laptops and open-standard USB-compatible peripherals. Figure 3 explains the different types of complementarities and ecosystems. For being an ecosystem, either unique or Supermodular complementarity is needed in both production and consumption (Ibid., 2265).

Type of complementary in production				
	Supermodular	3G- and 4G-compatible networks and devices	5G-compatible IoT product systems	Open-source software such as Android
	Unique	computer laptops and open-standard compatible peripherals	Solar photovoltaic panel, racking producers and installation providers	Apple iOS and compatible apps; Nike products and connected wearable
	Generic	sartorial accessories	cars and tires; tennis rackets and tennis balls	eBay; Airbnb; Uber
		Generic	Unique	Supermodular
		Type of complementary in consumption		

Figure 3. Types of complementarities and ecosystems with examples (Jacobides, Cennamo et al. 2018). Ecosystems are the blocks colored grey.

Interestingly, Gusumano, Gawer and Yoffie (2019) are looking at the same phenomenon from a different angle. They define two basic types based on the primary function of the platform: transaction platform and innovation platform. The most typical platform type is a transaction platform, where the value is captured from different market side interactions. In the core of innovation platforms are the third parties that are innovating their own products and services and thus adding value to the platform. It is also possible to combine these two platform types, which is called a hybrid platform. (Ibid., 66.) All these three platform types fall into a category of the multi-sided platform since there are different user groups included. The two types and their combination are presented in Table 4.

Transaction platform	**Hybrid platform**	**Innovation platform**
value creation by facilitating the buying and selling of goods and services	combination of transaction and hybrid platform	value creation by facilitating the development of new complementary products and services

Table 4. Different platform types (adapted from Cusumano, Yoffie et al. 2019, 19).

When comparing these two frameworks, some notions arise. It seems that the transaction platform falls into the category of generic production – supermodular consumption and thus does not be an ecosystem based on Jacobides' et al. framework. On the contrary, innovation platforms are based on a combination of supermodular consumption with unique/supermodular production; hence they are defined as ecosystems.

What are the consequences of opening the platform to external third parties? In the research of open innovation in the digital platform context, Hilbolling (2019) found, that these actors are profoundly changing the connections of the platform. Besides leveraging the connections inside the platform, external actors are also connecting platforms to each other's, thus creating the ecology of platforms (Ibid., 10). This leads to the management challenge: how to coordinate open innovation as part of a platform strategy? A strong, modular architecture is needed for proper functioning in different situations and configurations (Jacobides, Cennamo et al. 2018, 2260). It is crucial to maintain focus and user satisfaction, especially when new connections and possibilities emerge.

2.1.2. Components of platform strategy

Platforms can be considered through traditional strategy models, but these models are not explaining the whole phenomenon of platforms: new kind of strategic thinking is needed (Constantinides, Henfridsson et al. 2018, 9). Platforms that are driven by demand economies of scale and positive network effects emphasize the user amount of platform over traditional key performance indicators (Parker, Van Alstyne et al. 2016). It is even common to increase the user amount with unprofitable acts in the hope of later becoming a market leader and gain and even a unicorn.

What does network effect mean, where is the power of network effects based? There are four types of network effects: positive same-side, negative same-side, positive cross-side, and negative cross-side effects ((Parker, Van Alstyne et al. 2016, 29). The four types of network effects and their features are described in Table 5. The opposing effects can influence at the same time: for platform success, it is crucial which network effect dominate. The dominant network effect can change as the platform evolves.

Positive same-side positive benefits received by users when the number of users of the same kind increases	**Positive cross-side** positive benefits from an increase in the number of participants on the other side of the platform
Negative same-side the disadvantage received by users when the number of users of the same kind increases	**Negative cross-side** the disadvantage from an increase in the number of participants on the other side of the platform

Table 5. Network effect types (Parker, Van Alstyne et al. 2016, 29-32).

In their book about platforms (2016, 29-32), Parker et al. use Uber as an example of different types of network effects. *Positive same-side effect* happens when more customers join the platform, and hence ridesharing and cheaper rides become more available. *Positive cross-*

side effect is in both directions: the more demand (customers), the more attractive for drivers (offering). The more there are drivers, the more there is offering, which improves quality for customers and adds attraction. When the platform expands, negative effects usually get stronger. *Negative same-side effect* influences both sides of the platform. When the number of drivers increases, there is more competition and higher wait time. If the relative number of riders rises, there is more competition and a higher price. *Negative cross-side effect* means that if the number of drivers increases, downtime goes up and leads to higher prices for riders.

Parker et al. (2016) offer a comprehensive overview of the platform's anatomy. They emphasize the following subtopics: platform architecture, launch, monetization, openness, governance, metrics, strategy, and policy. These aspects are briefly explained in Table 6.

Architecture	
Participants	Platform has at least two sides: the one, that creates value (a producer) and the other that consumes value (a consumer).
Value unit	Producer creates value unit, something that is valuable for the consumer side of the platform.
Filter	The value unit is delivered to selected consumers based on filters. A filter is an algorithmic tool that – when well-designed – delivers only relevant value units for platform users.
Launch	Multi-sided market has to solve a chicken-or-egg dilemma. There are many strategies for overcoming the dilemma. In general, pull strategies are more important than push strategies (such as advertising).
Monetization	Monetization is about capturing a portion of the excess value created by the platform. For managing the network effects, it's important to choose whom to charge and whom to subsidize.
Openness	There are three levels of openness: managers/sponsors, developers, and users. The more open platform may provide more value, but they also need more curation for maintaining the quality of the platform.
Governance	Governance's function is to prevent market failures. The tools of governance are laws, norms, architecture, and markets. The goal is to encourage positive behaviors and discourage bad interactions.
Metrics	Metrics should focus correctly. The focus of metrics varies depending on the maturity of the platform.
Strategy	There is a competition in three levels: platform against the platform, platform against partner, and partner against the partner. Some methods for winning the competition are preventing the multihoming, fostering innovation, and enhanced platform design.
Policy	Some kind of regulation is needed for both economic and societal aspects. The policy should be carefully designed to catch the specialties of the platform economy.

Table 6. The anatomy of the platform (Parker, Van Alstyne et al. 2016).

2.1.3. Platforms in the housing context

Even though construction is an enormous industry, there are no popular global platform businesses known by the author. This may result because of the fragmented industrial field, multistage, and complex processes with multiple stakeholders and local regulation, to name a few. However, considering domestic examples, there is a clear trend towards servitization and platform thinking. These examples show that the transaction platform is overrepresented compared to the innovation platform.

Urakkamaailma.fi is a platform that connects renovation needers and contractors. It is targeted for both private families and housing co-operatives, and, based on their own website, it is a leading service for finding a contractor (urakkamaailma.fi 2020). The platform is a typical transaction platform, where the profit is collected from matching the demand -offering sides. The platform is free for buyers. The contractors can also join to the platform without charge, but they are charged the matchmaking fee when they catch a contract. There are some prequalifying steps for the contractors. Buyers are emphasized to rate the contractors for trust-building reasons.

Another Finnish example is YIT Plus Market Square (Palvelutori) that the construction company YIT offers for inhabitants living in apartment buildings constructed by them (YIT Oyj 2020). The company has gathered for the platform many service providers, from house cleaners to childcare and electricity agreements. Because of the centralized agreements between the company and service providers, the company offers lower prices and trustworthy service for the inhabitants. This platform is another example of a transaction platform. The monetization is not revealed, but presumably, the platform owner (the construction company) is taking a matchmaking fee from service providers once the job is got. In addition, some kind of access fee may be charged by service providers for joining the platform.

Finnish rental housing company Kojamo has developed its own words, "a service and innovation platform" that is close to YIT's platform (Kojamo Oyj 2019). On the contrary, instead of just matching the producers and consumers, Kojamo emphasizes the cooperative development of services with their collaborators. This means that the innovation platform aspect is included here. When considering the whole features, a hybrid platform would be the best description of it.

2.2. The basics of systems thinking and system dynamics

2.2.1. The world through a systemic view

The world is not simple. As everything is connected to everything else, a holistic worldview and widening one's understanding is needed for navigating in different situations. As Sterman (2000, 4) puts it: *"...learning about complex systems when you also live in them is difficult. We are all passengers on an aircraft we must not only fly but redesign in flight."*

In his famous book *The Fifth Discipline*, Peter Senge (2006) argues that organizational learning consists of five learning disciplines: systems thinking, personal mastery, mental models, building shared vision, and team learning. The book's name is linked with systems thinking, as this "fifth discipline" integrates other disciplines and makes the whole exceed the sum of its parts. Because of the more complex and dynamic world, more efficient ways of learning are needed.

Each learning discipline includes three distinct levels: (1) practices: what you do, (2) principles: guiding ideas and insights, and (3) essences: the state of being of those with high levels of mastery in the discipline (Senge 2006, 373). For systems thinking, practices (1) mean that one uses "system archetypes" to understand underlying structures in complex situations. Principles (2) represent the theory behind the practices. In a systems approach, principles such as "structure influences behavior" and "policy resistance" are central principles. The third level, essence (3), differs compared to previous ones. Instead of others, this state of being cannot be consciously practiced. The more one understands about systems thinking, the more she experiences interconnectedness and holism. (Ibid., 376.)

The roots of systems thinking lie in a critique of reductionism at the beginning of the 20th century. In reductionism, the phenomenon is split into smaller parts, and these parts are examined for getting knowledge. Conversely, systems thinking sees phenomena as a part of the whole organism (Ison 2008, 143.) Flood (2010, 269-270) writes: *"Emergence and* *interrelatedness are the fundamental ideas of systems thinking. An emergent property of a whole is said to arise where a phenomenon cannot be fully comprehended in terms only of properties of constituent parts. 'The whole is greater than the sum of its parts', is the popularised phrase that explains emergence. 'Synergy' is the sexy label for it. With systems thinking, then, it is argued that valid knowledge and meaningful understanding comes from building up whole pictures of phenomena, not by breaking them into parts."*

Systems thinking is based on the thought that systems are social constructs. Two different systems approaches can be found: (1) actual real-world entities and (2) conceptual constructs. Also, the terms 'hard' and 'soft' systems thinking are used (Reynolds, Holwell 2010, 7). Basic concepts of systems thinking include conceptual modeling, mapping, model boundary diagrams, subsystem diagrams, causal loop diagrams, and stock and flow maps (see Sterman 2000).

2.2.2. Principles of system dynamics

After the emergence, system thinking was soon adapted to different fields. John Forrester developed system dynamics in the 1960s at MIT. System dynamics has its roots in systems thinking, but it stretches towards the computer-aided simulation of complex systems. In his book *Industrial dynamics* (1961), Forrester argued that systems' behavior could be explained with flows, delays, and feedback relations. The methodology was very successful in its early years, culminating in publishing *The limits of growth* by Meadows et al. (1972). After the criticized model, SD went into decline until coming to fore again in the 1990s (Mingers, White 2010, 1150).

Apart from other systems thinking forms, system dynamics uses simulation. Simulation is an inseparable part that complements the model-basis analysis (Größler, Thun et al. 2008, 378). Why is simulation essential? Even though the qualitative tools for causal relationships are useful for visualizing mental models, there is still a lot of uncertainty inbuilt in omitted parameters, external inputs, and initial conditions. Since the mental models are far too complex for understanding their implications, the simulation is the only way to test the models (Sterman 2000, 37). With exploring different scenarios, it is possible to understand the system change over time (Harrison, Lin et al. 2007, 1238)

System dynamics is a highly practical discipline. Typically, the starting point of a modeling process is in a real-world situation and problem. It is essential to thoroughly understand the problem and, based on that, define the boundaries of a model. Besides, it is also crucial to identify the variables that are affecting a system (Dooley 2002, 14). After problem configuration, the problem is modeled first with qualitative methods and then formal modeling. The model is then used for simulating different scenarios and analyzing the dynamics of the system. Based on simulations and model analysis, policy recommendations are given for solving the problem.

The complexity of a system is not in the complexity of the components but in their relations. These relations are often organized in feedback loops, either positive or negative. Positive (*reinforcing loops, R*) feedback loops generate growth and amplify whatever is happening in the system. On the contrary, negative loops (*balancing loops, B*) are self-limiting, seeking balance and equilibrium. (Sterman 2000, 12.) Another central concept of system dynamics is stock and flow. Stocks describe the state of the system, giving inertia and memory to the system (Ibid., 192). Stocks are adjusted through flows.

When considering real-world problems and organizations, there is a need for involving stakeholders to system dynamic -based processes. These practices are called as Group Model Building. Scott (2018) builds a theory for group model building based on his own research in New Zealand. Scott emphasizes the importance of group decision-making in management and governance and suggests that these social processes can be helped with the tools of system dynamics (Ibid., 119).

2.3. Systemic development of platform business

In their article about digital platform research, De Reuver, Sorensen and Basole (2018, 128) emphasize the importance of methodological choices. Because of the complexity and dynamicity of platform ecosystems, the traditional reductionist approach should be avoided. Instead, network analysis and computational modeling are recommended in order to achieve a holistic understanding of the platform (Ibid., 129). As discussed in the previous chapter, systems thinking and system dynamics answer exactly to these methodological requirements. In this chapter, platforms are considered through a systemic world view. But before going there, modeling and simulation in the management context, in general, is handled.

2.3.1. Modeling in a management context

Despite the power of formal modeling in complex social systems, these methods are not vastly adapted to the field of management (Harrison et al. 2007, 1232). In their research of simulation modeling in a management context, Harrison et al. (2007, 1232) emphasize the formal modeling as it *"provides a different perspective on a research problem, and this fresh look often proves insightful in and of itself."* The model can be used for prediction, proof, discovery, explanation, critique, prescription, or empirical guidance (Ibid., 1238), thus giving a powerful tool for learning and adding understanding.

Simulation models can be categorized into three types: (1) agent-based models, (2) system dynamic models, and (3) cellular automata models (Harrison, Lin et al. 2007). On a literature review about simulation in management, Jahangirian, Eldabi et al. (2010) found that system dynamics is especially used in strategic decision-making levels such as strategy development and knowledge management. SD also created a strong engagement compared to other simulation techniques amongst stakeholders due, for instance, to its standardized conceptual modeling (Jahangirian, Eldabi et al. 2010).

Mingers and White (2010) list the recent contribution of systems thinking to management science and operational research. As a sub-concept of systems thinking, system dynamics is considered amongst other paradigms. Over the years, SD has become relatively isolated from management research, even though some concepts of SD are nowadays almost ubiquitous. However, it has been proved to provide a powerful set of concepts for modeling complex systems in a vast field of application. (Ibid., 1150.) With SD, it is possible to study the effect of business reengineering in various ways (Hajiheydari, Zarei 2013).

2.3.2. Digital platforms as systems

When considering platforms from a systems perspective, network effects seem to have a crucial role. Casey and Töyli (2012) analyze the strategic management of the mobile communications platform from the viewpoint of a platform owner. After describing the system, a conceptual formulation of the feedback structure is formulated (see Figure 4). This causal loop diagram involves both cross-sided and same-side effects. For innovation adoption, Bass' diffusion model is used. This popular model describes the adoption of new innovation and solves the startup problem by adding external information sources in order to attract the first adopters (Sterman 2000, 332). In conclusion, understanding the dynamic complexity is essential when considering subsidizing and revenue sharing decisions (Casey, Töyli 2012, 714).

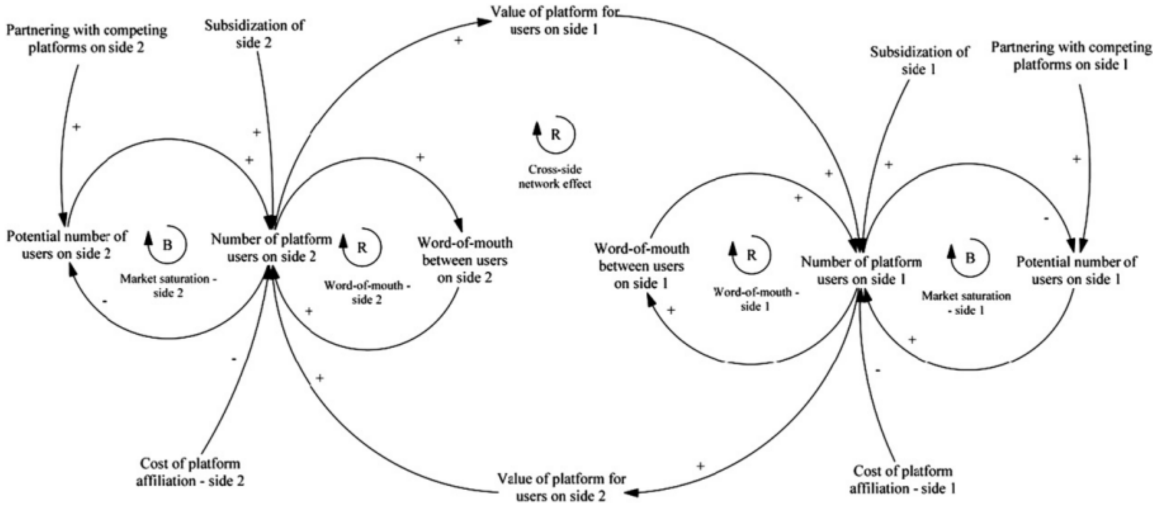

Figure 4. Causal loop diagram of mobile communication platform (Casey, Töyli 2012).

Another example of system dynamics view for the platform economy is research by Ruutu, Casey, and Kotovirta (2017) about the development and competition of digital service platforms. The article examines platform competition on Mobility as a Service -context. The crucial elements in platform competition and development are achieving critical mass, winner-takes-all -tendency, and the relationship of competition and coopetition (Ibid., 120). A causal loop diagram of the system is developed (Figure 5). A total of four feedback loops are discovered, of which three are reinforcing (positive) loops, and one is balancing (negative) loop. Two of the feedback loops are network effects: positive cross-side effect between different user side, and positive data network effect.

Based on simulations, three different scenarios are explored. Many policy recommendations are given, covering, for instance, the lock-in mechanism of data gathering and the effect of transferability of data. Research limitations include the question of obsolescence of a specific platform business model used. Also, being a generic model, the research does not give specific policy advice for platforms in a unique context. (Ruutu, Casey et al. 2017).

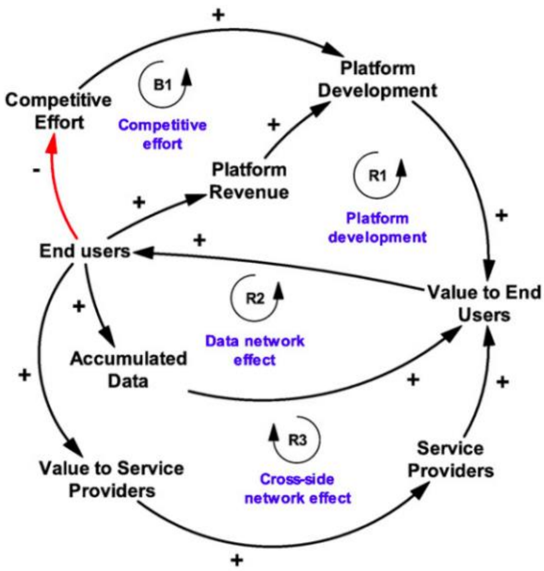

Figure 5. Main feedback loops related to platform development (Ruutu, Casey et al. 2017, 121).

There is also research about competing platforms with real historical data. Arzoglou, Elo and Nikander (2019) are developing a system dynamics model about the competition of iOS and Android, which includes both users and developers. The work is still under progress, but the research design and initial results seem promising.

2.3.3. Business development using system dynamics

Business models are needed to commercialize new ideas and technologies of the firm. With the same resources, it is possible to end up totally different economic outcomes through various business models. The ability to innovate business models is usually far behind the abilities of technological and idea innovations (Chesbrough 2010, 354). As Chesbrough (Ibid., 355) puts it: *"In fact, it is probably true that a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model."*

The idea of a business model is old, but it became more common in the 1990s as Internet time started (Zott, Raphael et al. 2011). The business model concept enables new types of innovations (such as platform businesses), reconfiguration of current business models, and social and environmental value creation (Massa, Tucci et al. 2017).

The explicit, formal conceptualization helps to deal with the complexity. Simplification supports communication by showing the essential and helps also measuring and prediction (Massa, Tucci et al. 2017). As Osterwalder and Pigneur (Osterwalder, Pigneur et al. 2010) define: *"A business model describes the rationale of how an organization creates, delivers, and captures value."*

It is also possible to examine the business model phenomena in meta-level by defining the essential components of the model. Business model canvas (BMC) is an approved example of this (Massa, Tucci et al. 2017). The business model canvas was first introduced by Osterwalder and Pigneur in 2010. BMC includes a total of nine elements: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partners, and cost structure (Osterwalder, Pigneur et al. 2010).

The concept of business model has been criticized for being too static to capture the dynamics of the real world (Khodaei, Ortt 2019). One way to tackle this problem is through the use of simulation. Axelrod (Axelrod 1997) emphasizes many valuable aspects of simulation, such as prediction and training over time.

Cosenz and Noto (Cosenz 2017, Cosenz, Noto 2018) have recently developed a concept of combining business model canvas and system dynamics, which they name Dynamic Business Model (DBM). In their article, Cosenz and Noto (2018) examine a startup firm using their tool. The presentation of the model is shown in Figure 6. In this framework, a system dynamics model is adapted on top of the business model canvas. All the variables are in their corresponding place of the canvas. There are five feedback loops total, two reinforcing, and three balancing. The feedback loops are shown in the figure with different colors.

The modeling aims to give a better understanding of the business operation and value creation, thus enabling suggestions for sustainable development and success of the startup. More specifically, the analyzed scenarios are related to the relationship between financial resources and marketing investments. There are three scenarios: 50%, 75%, and 95% of the financial resources invested in marketing (Cosenz, Noto 2018, 135). As a result, the third scenario, with 95% of invests turns out to be the only sustainable scenario.

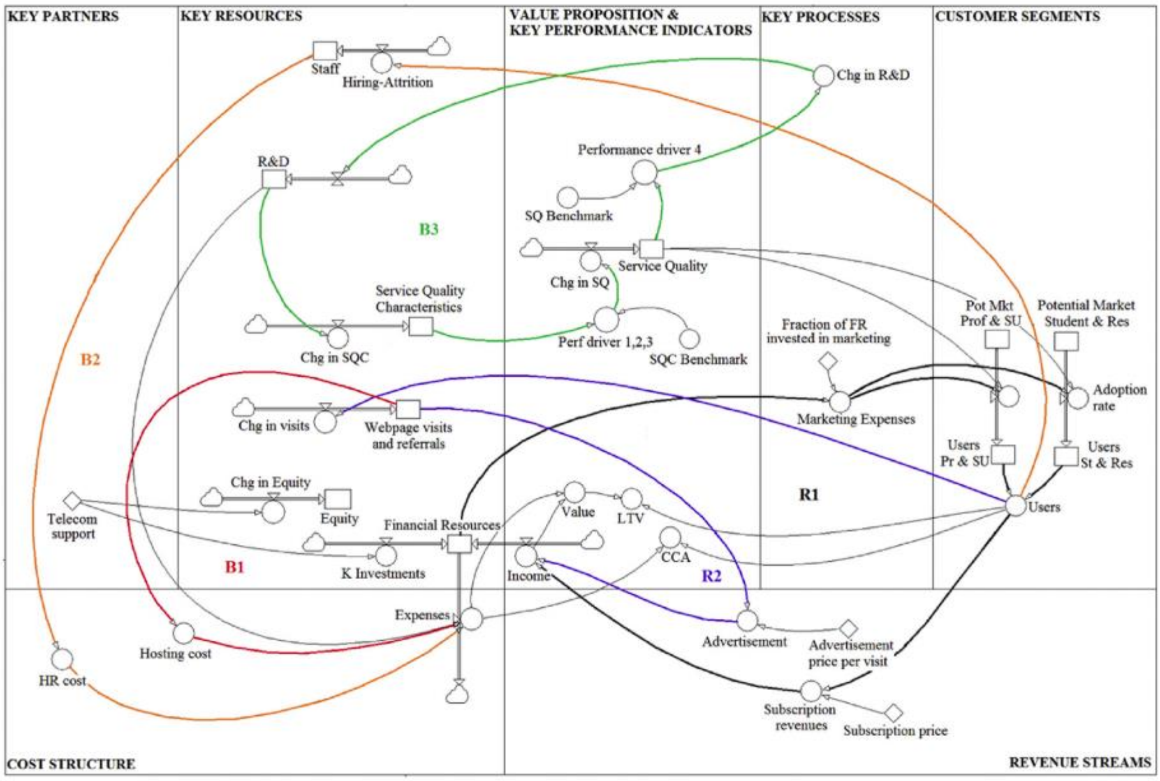

Figure 6. System dynamics model of a startup firm (Cosenz, Noto 2018).

In the conclusions, Cosenz and Noto (Cosenz, Noto 2018) reflect the research process. While there were difficulties in understanding the feedback structure, the managers of the startup found it useful to test different strategies with the model (Ibid., 138). Because of the commonness of the business model canvas, the framework developed gives a practical way to widen the static model towards dynamic understanding.

There are also other studies of business development using a systems approach. Others use qualitative methods, while others end up with formal modeling. Abdelkafi and Täuscher (2017) have studied sustainability in business models using a system dynamics perspective;

Groesser and Jovy (2016) have developed a startup company also with formal modeling and computational simulation, and Täuscher and Chafac (2016) have adopted systems thinking to scenario-based business model decisions.

3. RESEARCH DESIGN AND THE MODEL DESCRIPTION

In this chapter, the case is presented, and the research methodology with data gathering and analysis are considered. Finally, the modeling process is described.

3.1. Case description

A typical housing development case is a multi-phase process with multiple stakeholders. There are many variations of the process, but one typical example is presented: First, there is a landowner who wants to monetize her land property. She starts to seek the developer, who makes a preliminary agreement and carry through the housing development process. (The start can also emerge another way round: there is, for example, a global investor, who is seeking residential plots to develop. In this scenario, the developer contacts the landowner). In either case, there is now a building plot with a developer. If the town plan is outdated, the next phase is to refresh the town plan. This may take several years, depending on the city's interests and resources. The better the development project is in line with the city's goals, the smoother and faster the process is. Usually, the preliminary design of the project serves as a guideline for the town planning.

When the town plan is updated, it is time to finish the design and apply for the building permit. When the permission is admitted, the actual marketing of the apartments starts. After a couple of months or so, the critical mass of bookings is fulfilled (usually about 50 % of the apartments), and the construction can begin. The contractor can be the same company that has developed the project so far, but it can as well be another company. In the construction phase, there are sub-contractors and suppliers included also. After one year of building or so, the apartments are ready to be given for the new inhabitants.

As the description of the typical process reveals, the housing development business is based on the producer side's activity. The design of the apartments and the whole project is based on the assumed preferences of customers. After designing and building permission, ready and fixed apartments are pushed to markets in the hope that there are enough interested customers (demand).

This status quo described above has led to the situation that not everyone is satisfied with the current market offering. In a resident survey from Helsinki (Hirvonen, Manninen et al. 2005) the suitability of the apartment was a critical choice argument. Around 30% of the interviewed experienced a lack of the possibility to influence. Also, ten to thirty percent of residents would have considered paying more in order to get more decision-making power to the apartment. Another topic of discussion is the high price of new apartments. Recently, the CEO Juuso Hietanen of a construction company named Bonava compared the housing markets of Helsinki and Berlin (Taipale 2020). The average square price in Helsinki is around 6000 euros and in Berlin 3500 euros. According to Hietanen, the biggest problem is old-dated town planning practices. Being true or not, there is a vast consensus of decreasing the prices of new apartments.

In platform-based housing development, this producer-centric push market is turned upside-down to a consumer-based pull market. What do the customers need and demand? There are many natural demand – offering matches (or consumer-producer matches) in the housing development process. However, in this research, the focus is on the relationship between landowners (residential plots, basically location) and apartment seekers. Figure 7 presents the interaction between these two market sides. Above, there are apartment seekers with diverse preferences. There are, for instance, singles, families, investors, and communities. Someone prefers a good location next to hobbies, another one values services, or an active community. Someone affords rooftop apartments, while others seek a rental one-bedroom apartment.

On the other side of markets are the ones who govern land property and want to develop it. There are, for instance, private landowners, real estate developers, cities with land property, and apartment house companies interested in complementary building. Their interest is to sell the land property as fast, easy, and high price as possible.

The mediator between these two market sides is a platform, here named as *the housing platform*. The platform allows landowners to upload their residential plots to the platform easily, and apartment seekers to choose a suitable apartment from some of the locations offered by landowners. But how are the residential plots changed to apartments? The basis of the housing platform lies in a modular apartment library. The library includes tens or hundreds of apartments that fit modularly together. Apartment seekers choose the apartment form the library based on their preferences, and all the chosen apartments are put together to form the apartment building that fits for the specific residential plot. This integration is thought to happen by algorithms using generative design, although there is undoubtedly a need for human professionalism also.

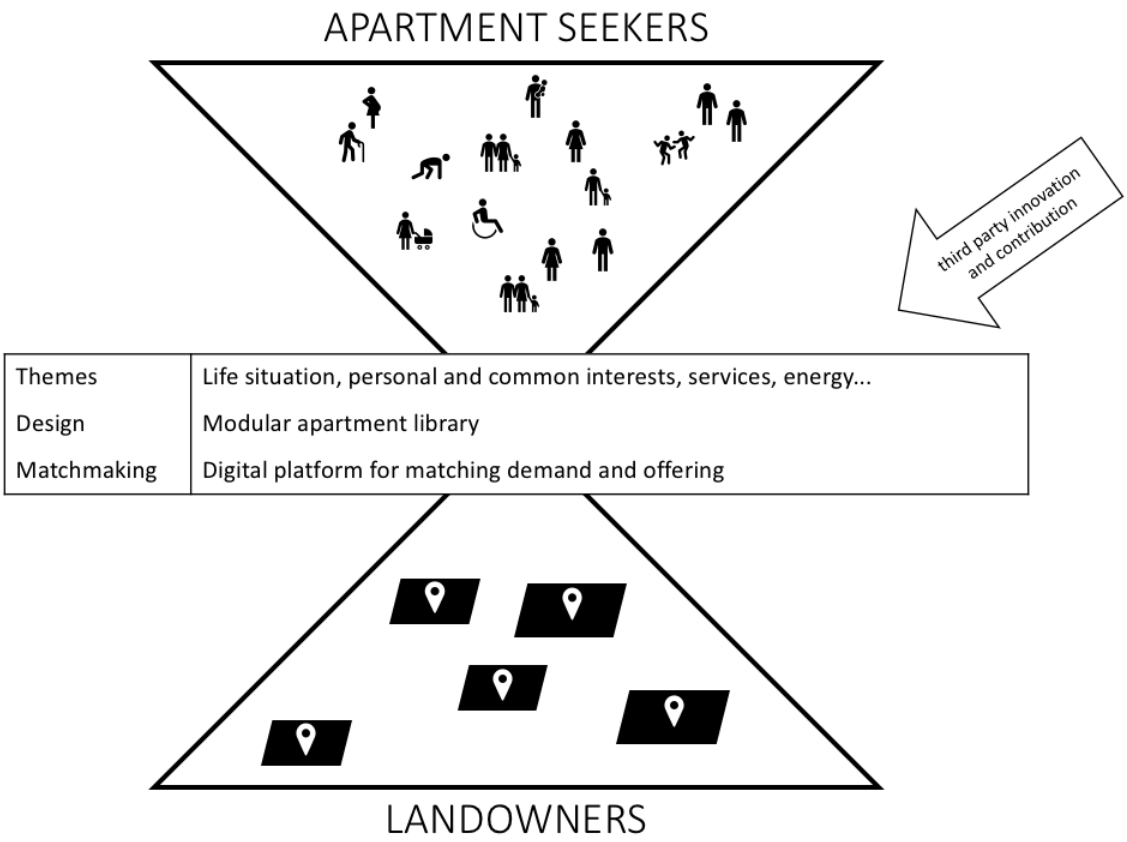

Figure 7. The two sides of the housing platform and platform value proposition.

For whom is the housing platform for? One main restriction is that the platform is only for apartment buildings. All kinds of governance models can be included in the platform: owning, rental, housing co-operatives, right-of-occupancy dwellings, joint building ventures, and HITAS, a price-and-quality control system in Helsinki. Thus, no market sectors of apartment seekers are out of the platform. For the landowner side, the limit is defined by the apartment library: what kind of residential plots can be designed with the library? In addition to the technical aspect, design quality needs to be taking account also. What are the apartment buildings like? Are they aesthetically acceptable for the city center?

The quality and diversity of apartment options in the library also have a crucial effect on the apartment seeker side. From the suitability perspective of the apartment, the current apartment seeker market can be divided into two classes. First, there are apartment seekers that are satisfied with the current apartment offering. This class can be named as a red ocean, based on the definition of Kim and Mauborgne (2014). Another group is the ones who do not find an apartment with their personal preferences from the market (blue markets). Depending on the quality of the apartment library, apartment seekers from both groups can find a suitable apartment from the apartment library. Since the current apartment offering is quite homogenous, there is a good chance for creating previously nonexistent value to apartment seekers.

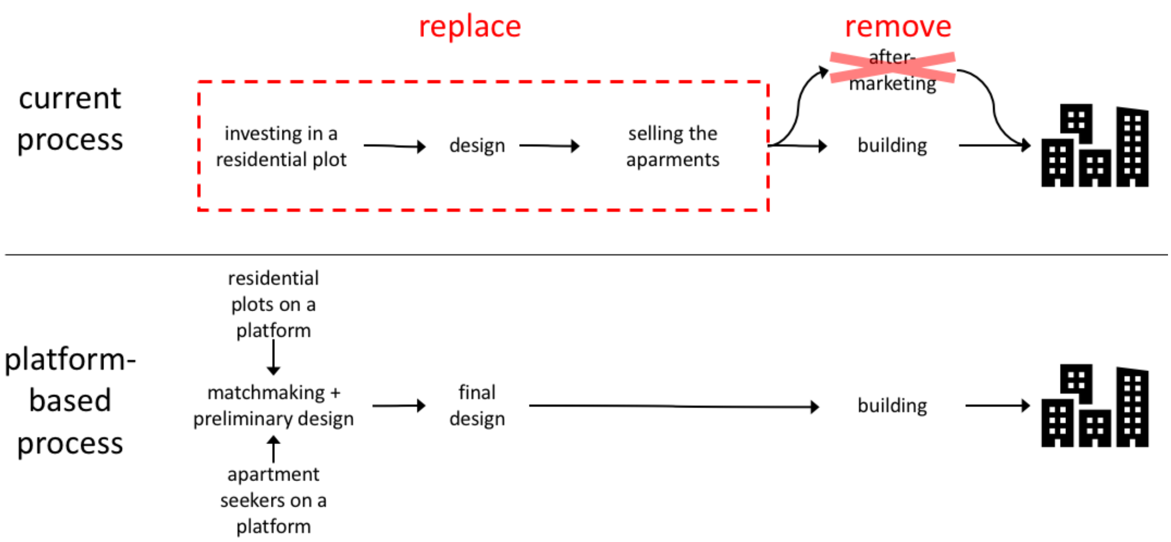

Figure 8. Current housing development process compared to the platform-based process.

If existing, the housing platform would have notable disruptive effects on the housing development value chain (Figure 8). The concept of disruption was introduced by Clayton Christensen in 1995, and it has since then gained vast popularity. Briefly, according to Christensen (2015, 8), disruptive innovations originate either in low-end or new-market footholds and, if successful, can change even the whole industries. The projects executed by the housing platform would not need a developer anymore. Also, there would not be a need for real estate agents, since customers are selecting their apartment themselves. Design costs would decrease because of modularity.

Another significant difference compared to the current process is the money flow. Usually, the developer takes a remarkable risk when starting the development process: much money is needed before the certainty of financial profit. Risk costs always, and here also, the risk increases the total price of the apartments. On the contrary, with the housing platform, the development process starts when there are already customers, i.e., buyers of the apartment building. Thus, the risk of the project is essentially smaller. Of course, some bridge financing may be needed during the construction process, but the costs remain a much smaller level.

The hypothetical benefits of the housing platform include the empowerment of inhabitants and financial savings. Time savings may also be possible, depending on the processes. After all, the platform strategy is either succeeded or failed depending on the potential financial advantages that the reshaped housing development process produces. With no savings, there is neither value to be shared nor captured in the platform ecosystem.

The research is commissioned by a Finnish construction company. The company has been developing a housing platform business model that is briefly explained above. The goal of this research is to develop further and evaluate the platform strategy and give guidelines for the future.

3.2. Research methodology

In this research, a system dynamics methodology is used. In system dynamics methodology, the problem under consideration is modeled, and then this model is used for simulation. Based on simulations, it is possible to give policy recommendations in different situations. Before dealing closely with the SD process, the nature of simulation is first discussed.

What is simulation? Simulation is a special type of modeling. Making a model is a popular way to simplify structure or system. Compared to modeling, simulation also has a time horizon: what happens to the system through time in certain circumstances (Gilbert, Troitzsch 2005, 2). The simulation also has its research methodology tradition. As a method of social research, there is usually some real-world phenomenon as a starting point. Gilbert and Troitzsch (2005, 15) define it as a *target*. The essence of the target is abstracted to a *model*, a simplified description of the original phenomenon. The model is used to generate simulation data based on different scenarios. This simulated data can then be compared to the collected data if it exists. (Gilbert, Troitzsch 2005, 16-18)

Harrison et al. (2007, 1230) define simulation as a third way of doing science with induction and deduction. Computer simulation enables “virtual” data and computational handling to mathematical relationships and thus overcomes the many problems that inductive and deductive approaches have. Harrison (2007, 1240) suggests a concept of “an interactive process of management theory and simulation modeling”, which shows that simulation can be a convenient tool in studying complex phenomena.

There are several ways to execute the simulation process (see Martinez-Moyano 2013, Luna-Reyes, Andersen 2003, Sterman 2000, Gilbert, Troitzsch 2005, Banks 1998). In this research, Sterman’s (2000, 86) five-step system dynamic process is used. The process includes the following steps: (1) problem articulation and boundary selection, (2) formulation of dynamic hypothesis, (3) formulation of a simulation model, (4) testing, and (5) policy design and evaluation. The process is presented in Figure 1. As the figure presents, the modeling process is iterative. This iterative process goes through the steps many times. Even though not shown in a figure, every single step can affect any other step.

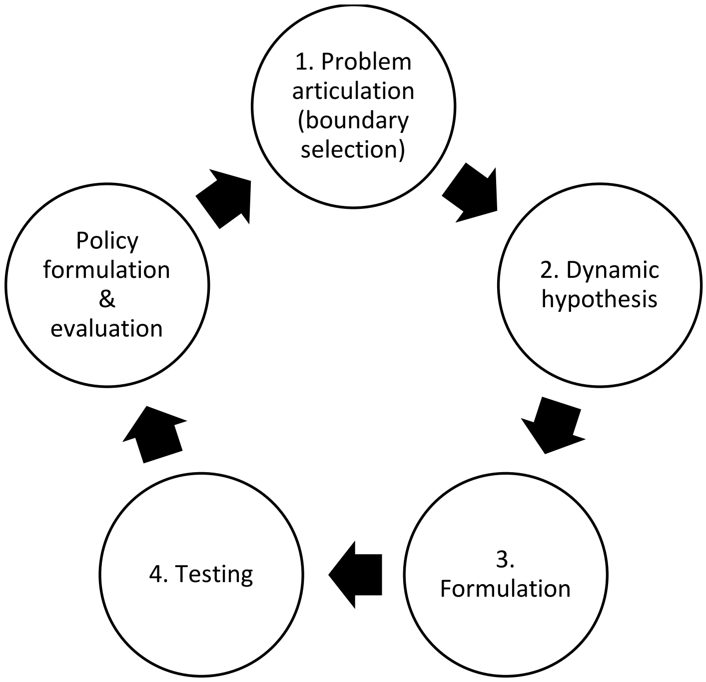

Figure 9. The system dynamics modeling process (Sterman 2000).

The modeling process starts with problem articulation (1). The efforts to model an entire business or social system are inevitably failing. Models are always a simplified presentation of a problem: without simplification, they would be as complex as the problem, and thus not giving any added value. Therefore, the main question is not what to include but what to exclude from the model. If the scope and boundaries of a model are in line with a problem, there is a good starting point for the modeling process.

After defining the boundaries, it is time to formulate a dynamic hypothesis (2). This means a theory-building, and the objective is to explain the problematic behavior. Term *dynamic* underlines that the theory must explain the underlying nature of the problem. The theory is a hypothesis since it is only provisional and to be replaced with a better one while the process goes on.

There are many ways to map the structure of a system. *Model boundary chart* lists endogenous, exogenous, and excluded variables, *sector map* reveals the major model parts and their relation, and *causal loop diagram* shows the single variables and their relations. Finally, *stock and flow map* emphasize the underlying physical structure of a system.

Based on a dynamic hypothesis, the simulation model is formulated (3). Simulation is needed to understand the real dynamics of the system. In order to be able to simulate, the conceptual model must be transformed into a specified formal model, which consists of equations, parameters, and initial conditions.

After simulating the model needs to be tested (4). Testing starts from the very first moment when starting to write equations. Every variable must have a real-world counterpart. When testing, the uncertainty in equations and structures must be assessed.

After the model is tested, policy formulation and evaluation (5) are executed. In this phase, the model can be used for giving policy recommendations. The policy design does not restrict only to the changing value of parameters, but besides, it can include new strategies, structure reshaping, and new decision rules.

3.3. Data collection and analysis

Due to the nature of research, the research process is made with active interaction with the commissioned company. Especially problem formulation is crucial for a successful simulation process. Therefore, much effort is needed in communication between researcher and client (Banks 1998, 15). A supervisor was named from the company, and conversations were numerous, especially during the data collection and analysis phase.

Different types of methods for data collection in case-study system dynamic processes have been suggested. Luna-Reyes and Andersen (Luna-Reyes, Andersen 2003) have studied the collection and analysis of qualitative data in system dynamics context. Depending on the research stage, different methods are recommended. There is also plenty of research under the term *Group model building* (see e.g. Scott 2018) that was handled shortly earlier in the theory part. GMB offers tools for involving stakeholders in the modeling process, and it is especially useful in case studies.

In this research, both qualitative methods suggested by Luna-Reyes and Andersen and group model building technics were used in data collection. There was a total of six personal interviews or meetings and two workshops, with a total of 11 participants. Table 7 presents the research steps and corresponding data gathering. The interviews and meetings were recorded, and the main points were written down. Also, if there was something visual created during the meetings, these documents were collected and documented by photographs.

Research step	**Data collection**	**Theme**
1. problem articulation and boundary selection	+ initial meeting and several other discussions with the supervisor and a couple of other professionals from the company	+ objectives and starting points
2. formulation of dynamic hypothesis	+ workshop I + interview + interview + interview + interview + interview + interview + workshop II	+ platform sides, network effects + company strategy, innovation platforms + joint building ventures + housing co-operatives, transaction platforms + housing markets, real estate agent’s perspective + platform strategy, disruptive innovation + disruptive thinking, business opportunities + scenarios, stock and flow diagram
3. formulation of a simulation model	(reflective discussions with professionals)	(development and evaluation)
4. testing	(reflective discussions with professionals)	(development and evaluation)
5. policy design and evaluation	(due to the timetable, the final discussion and evaluation of the research took place after finishing the thesis)	(evaluation and future steps)

Table 7. Research steps and data collection.

After the system dynamics model was constructed based on theory and data collected from the company, simulations were executed. For formal modeling and simulation, an open-source, web-based simulation program called InsightMaker was used. The quantitative data from simulations were then analyzed for the purpose of policy design and evaluation. As typical for the system dynamics modeling process, the modeling steps were overlapping each other. The formulation of a simulation model started practically at the same time with problem articulation, and the dynamic hypothesis was evolving until final simulations.

3.4. Validity and reliability

Models are always conceptualized and simplified reconstructions of the real world (Morecroft 2007, 1). It is impossible to model all the details that occur in reality. Instead, a good model is able to capture the core dynamics of the phenomenon. For evaluating the results and strengthening confidence, the modeling process needs to be presented in sufficient detail (Harrison, Lin et al. 2007, 1242). In this research, the model is presented according to the standard modeling process. There have been efforts for precise documenting, but, of course, it is not possible to describe all the hidden details and mental models behind the actual model.

For a successful system dynamic modeling process, a strong involvement of the organization is needed (see for instance Scott 2018). As Table 7 reveals, there has been quite a lot of interaction with the organization. However, some notions arise. Despite the several meetings, not all the modeling phases are equally handled with the organization. Especially in the last phase of the modeling process (policy design and evaluation) lacked structured and formal interaction. This was mainly caused by the chosen research methodology: System dynamics modeling process was new to the participants and for the research author also. It took longer than expected to get into the modeling and deeply understand what it is about. However, systems thinking was not totally unknown in the organization: systems intelligence (Saarinen, Hämäläinen 2007) serves as an important building block of the organization. This helped in choosing the systemic frame for the research and conducting it.

On the whole, I would argue that the qualitative objectives of the research, as well as the expectations of the commissioner, were satisfied at a reasonable level, taking into account the timetable and expected scope of the master’s thesis. Finally, it is not possible to validate the model: instead, it may be more descriptive to speak about usefulness or confidence (Sterman 2000, 846). In this research, the convincingness of the model and the study is tried to capture by rigor modeling process, previous theory, and discussions with modeling professionals. It is up to the reader to decide what weight to give to the results of his research.

3.5. The system dynamics modeling process

The modeling process follows the phases of system dynamics modeling described in the methodology part; sub-chapters are named based on the corresponding phase.

3.5.1. Problem articulation and boundary selection

The goal of the modeling was to examine whether and in under what conditions the housing platform will succeed financially. In other words, the purpose is to examine if the business idea of a housing platform is promising enough for further investments. Since the focus is on the single platform level, the main interest lies in the network effects of the platform: what are the dynamics of two-sided markets, and what is the realistic (or possible) user amount of platform?

When analyzing the potential of the platform, three fundamental parameters determine the success: what is the number of residential plots in a platform, what is the number of apartment seekers in a platform, and finally, how the demand and offering encounter (i.e. the number of matches). Various other parameters are needed in order to explain the dynamics of these two market sides. Another essential aspect is the importance of ecosystem and third-party innovation. Basically, the housing platform is a transaction platform. With the model, the objective is to analyze if there are incentives to develop the platform towards an innovation platform.

What about the operational environment? While some exogenous variables are inevitably included, the broader aspects of society and the business environment are mainly limited out of the model. These wider phenomena plainly explain some dynamics of the platform, but for the scope of the problem, they are not main explanatory issues. Therefore, the topics, such as stock markets and societal phenomena, are excluded. In addition, marketing costs are excluded because they are tiny compared to potential financial income.

Figure 10 presents the three user sides of the platform (in the case of a hybrid platform). The parameters next to each market side present the aspects the user considers when seeking an apartment or selling a residential plot.

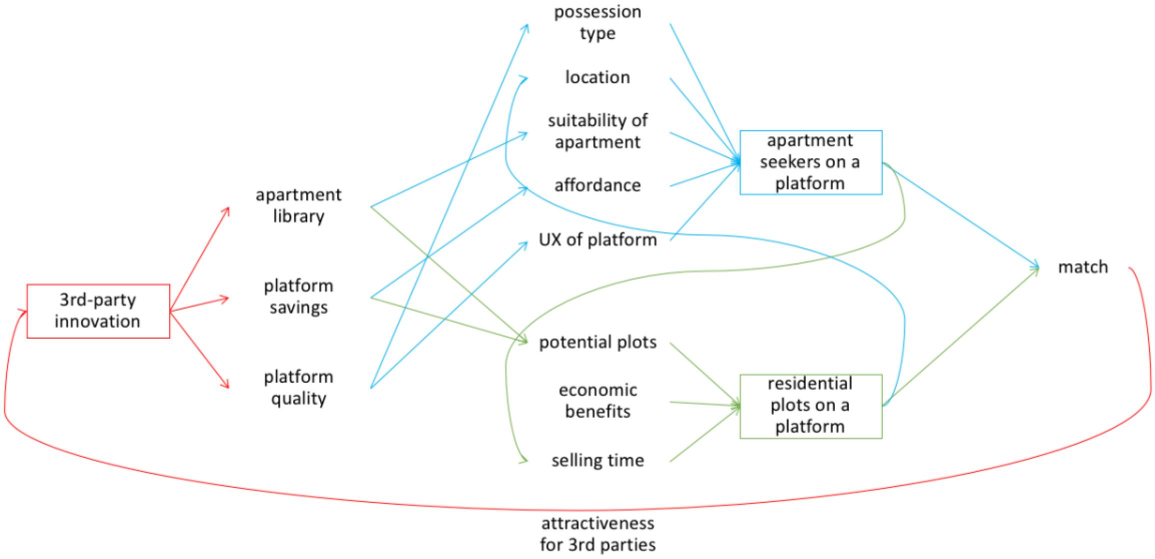

Figure 10. The three user sides and essential incentives of decision-making.

Considering further investments, it is also essential to somehow mirror the network effects to financial numbers. That is, the financial value of matches needs to be estimated: what is the average home price, and what is the matchmaking fee that the platform owner takes? Overall, the focus of the model is on the income side because it tells better the potential of the platform. If the potential is vast and clearly visible, there are no difficulties in financing and dealing with the costs.

A time horizon of the model is fixed to ten years. This is long enough for showing the dynamics and trends of a model but, at the same time, short enough that one can imagine it.

3.5.2. Dynamic hypothesis

Formulating the dynamic hypothesis was an iterative process, and it developed until the final simulations of the model. The hypothesis was constructed with different system dynamic tools. First, the sector map was defined, and then the network effects of the user side were explored. After that, the causal loop diagram of the actual system was formulated. In addition, some other key features of a platform are explained.

Sector map

The model can be divided into three distinct sectors (see Figure 11). Resources include both financial and data resources. With these resources, it is possible to enhance the quality of a platform. The platform quality consists of the apartment library (both size and quality), the quality of a platform itself (meaning mainly user experience and the matchmaking filter), and finally also the third-party innovation. Third-party innovators are defined here as part of the quality sector (since they are adding quality), but they could also be seen as users. The arrow between resources and quality is two-headed because the quality development needs resources. The quality is needed for attracting both market sides: apartment seekers and landowners. When there are users on a platform and matches emerge, resources are generated (both financial and data). The framework of dividing the platform into these three sectors is adapted from Ruutu et al. (2017) research.

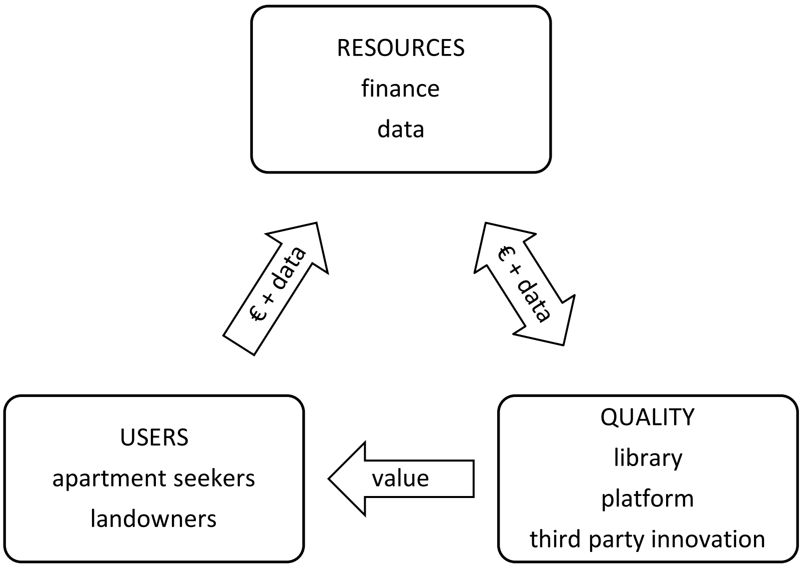

Figure 11. Sector map of the model.

Network effects

The systemic analysis of network effects covers the user sector, but third-party innovators are also included. The network analysis shows that there are multiple feedback loops, both positive and negative. For clarity, the feedback loops are named as NE (Network Effect) with a number. This prevents the confusion between a network effect map and an actual system map, which both have feedback loops. The network effects are shown in Figure 12. Different market sides (users) have a yellow background. Positive feedback loops are colored blue and negative red. Red lines represent a negative link between parameters, and grey lines and parameters represent the future possibilities of a platform.

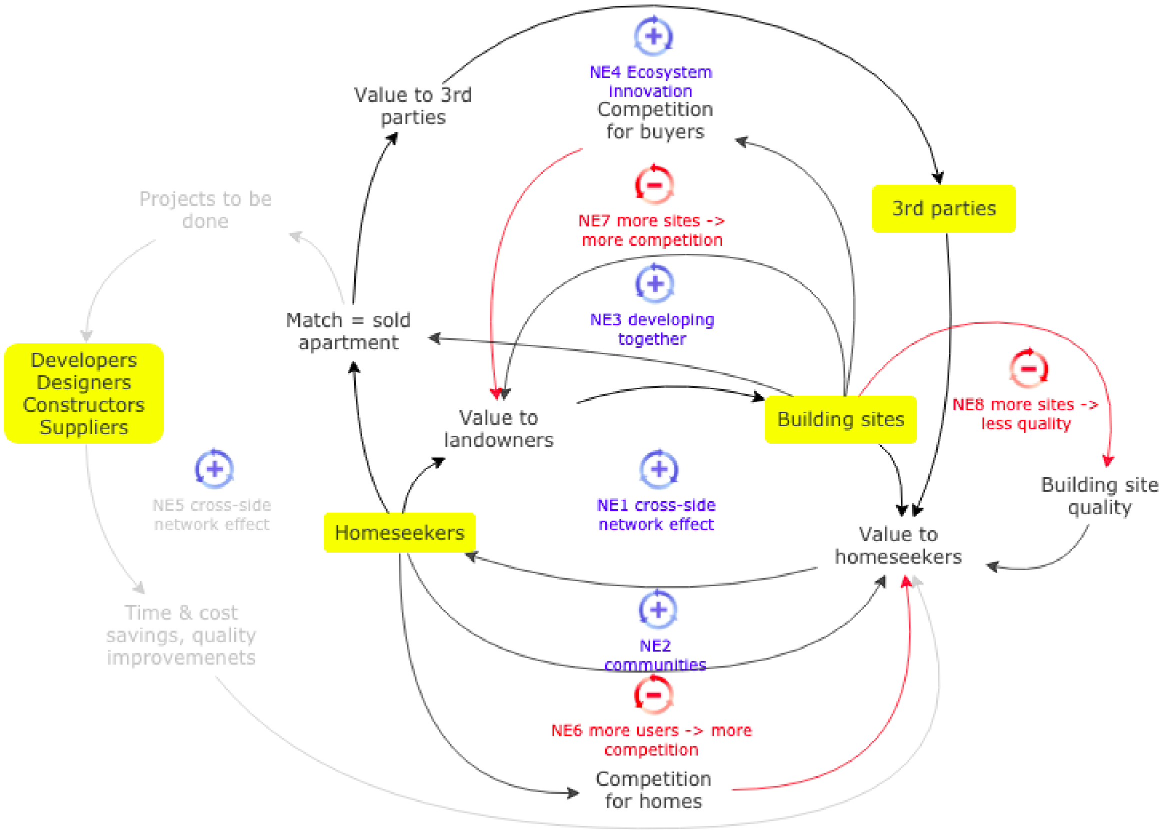

Figure 12. Causal loop diagram of network effects.

Reinforcing loop NE1 is the positive cross-side effect that apartment seekers and landowners have to each other's: the more apartment seekers there are looking for a home, the more appealing is the platform for residential plot owners, and vice versa. The second positive loop NE2 is a same-side effect on apartment seekers: the more seekers on a platform, the more common interests, and possible joint projects. The third positive loop (NE3) is a same-side effect on the residential plot side. When the number of plots on a platform increases, increases also changes to mutual development and value co-creation projects. The fourth loop (NE4) describes the positive effect of third-party innovation. This cross-side network effect combines "basic" users (home seekers and plot owners) to third parties. The last positive network effect is NE5, which presents the future possibilities of the housing development process.

There are a total of three negative feedback loops in the causal diagram of network effects. The first loop (NE6) describes the demand-side competition: the more users, the more competition of available apartments. The second one (NE7) describes the same effect on the producer side: the more residential plots on a platform, the fewer apartment seekers per plot. This feedback loop can lead to longer selling times and thus decrease the attractiveness for landowners. The third negative loop (NE8) is a cross-side effect between home seekers and landowners: The more there are residential plots on a platform, there is a risk of quality decline of the plots. This can lead to a less attractive platform for apartment seekers' point of view.

Network effects and their explanation is summed up in Table 8. While network effects are one of the main determiners of platform dynamics, they are not equally relevant from the viewpoint of research focus. The information whether a single network effect is included in the actual system model or not is also given in a table.

Network effect	**Explanation**	**In SD model? (+ / -)**
NE1 (reinforcing cross-side)	The more apartment seekers there are looking for a home, the more appealing is the platform for residential plot owners and vice versa.	+ Most important network effect.
NE2 (reinforcing same-side)	The more apartment seekers on a platform, the more common interests, and possible joint projects there are.	(+) Included as a feature of the Bass diffusion model.
NE3 (reinforcing same-side)	When the number of residential plots on a platform increases, increases also changes to mutual development and value co-creation projects.	(+) Included as a feature of the Bass diffusion model.
NE4 (reinforcing cross-side)	The positive effect of third-party innovation. This cross-side network effect combines "basic" users (apartment seekers and residential plot owners) to third parties.	+ Cumulative data attracts third party innovators, which leverages the value of the platform.
NE5 (reinforcing cross-side)	The future possibilities of the housing development process.	- This subject is delimited out of the research. See chapter 5.
NE6 (balancing same-side)	The more apartment seekers, the more competition of available apartments.	- Based on comparisons (e.g. oikotie.fi), not a strong feedback loop.
NE7 (balancing same-side)	The more residential plots on a platform, the fewer apartment seekers per plot.	+ Sufficient demand is critical for platform success.
NE8 (balancing cross-side)	The more there are residential plots on a platform, the bigger the risk of quality decline of plots.	- Can be controlled through curating.

Table 8. Network effects and features.

Main feedback loops of the model

The causal loop diagram of the system to be modeled is presented in Figure 13. The feedback loops are presented with a stronger black line with + or – sign in the middle of the feedback loop. The three sectors of a model are also included in a figure. In a grey color, the complementary variables are presented. These will be explained later.

There are five feedback loops involved in a final model. Three of those are network effects that are already presented in the network causal loop diagram (Figure 12). First feedback loop R1 is a cross-side network effect between apartment seekers and landowners. When there are apartment seekers on a platform, this demand attracts landowners to put their residential plots to the platform. This adds the apartment options and leverages demand-side attraction.

There are two reinforcing feedback loops linked to platform development and the role of data in it (R2 and R3). Accumulated data correlates with the cumulative number of matches. This data can be used to enhance the platform quality (R2): the filtering algorithm gets better with data, and also user experience and user interface can be developed further when analyzing the gathered data. The other data effect relates to the apartment library (R3). The quality of homes is initially already relatively good, but it is possible to develop it further by analyzing user preferences.

The fourth positive feedback loop is third party innovation loop (R4). Cumulative matches cause to accumulate the data. When there is enough data (in this case, the cumulative number of matched apartments), the third parties begin to see value potential in a platform. When third-party innovation occurs, it adds platform value for apartment seekers in two ways: extra value and additional savings. The hypothesis of extra value is based on the thought that third parties can contribute to community building on a platform, for instance, through developing apps for community enhancement and thus add value for apartment seekers. Additional savings mean that third parties can integrate, for instance, their financial or energy innovations to the housing development projects of the platform. Platform governance and openness play a central role in defining whether the potential of third parties is enabled or not (see grey variable pointing to "value to 3rd parties" in Figure 13). When adding third-party innovation to the system, the transaction platform evolves towards a hybrid platform (Cusumano, Yoffie et al. 2019) .

In a model, there is one main level negative feedback loop (B1). This negative same-side network effect affects the landowner side, and it is already presented in network analysis. The more residential plots there are on a platform, the fewer are the apartment seekers per plot. This lengthens the selling time of apartments and thus diminishes the attractiveness of a platform for landowners.

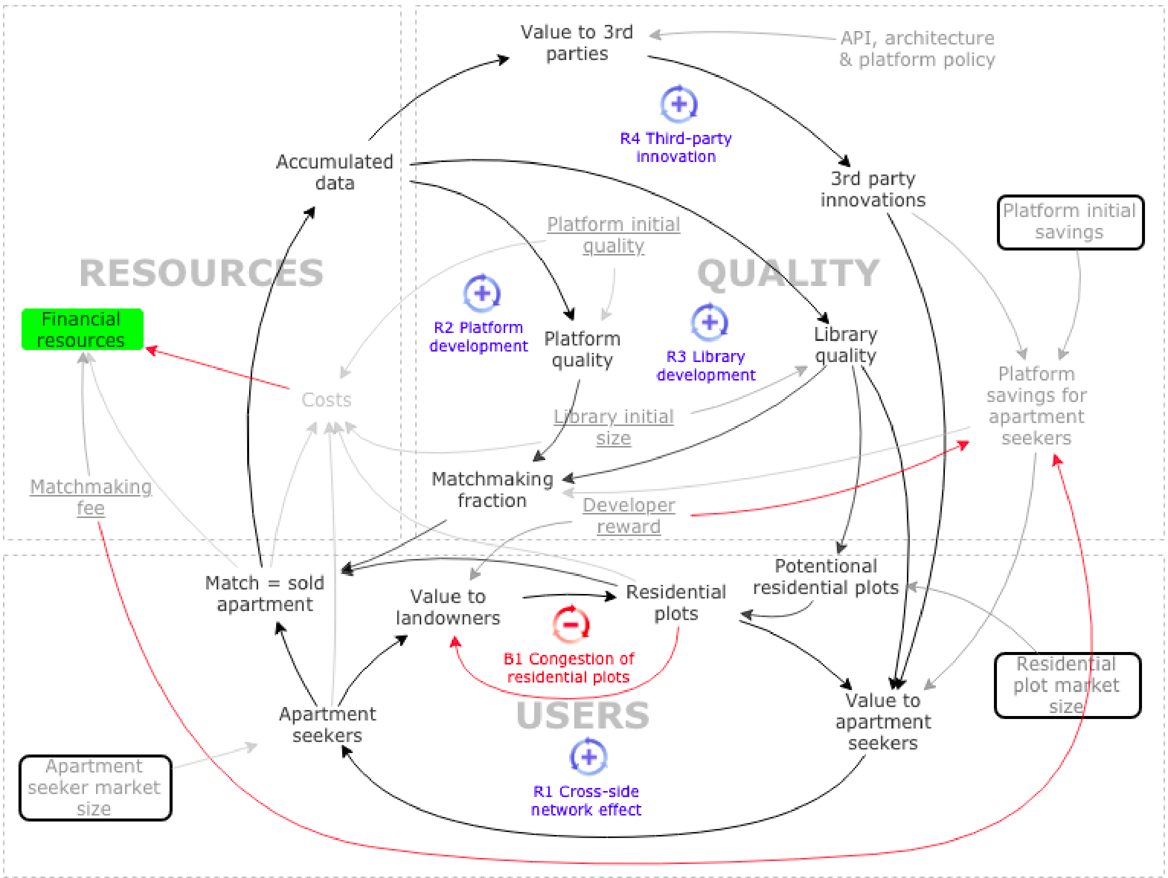

Figure 13. Causal loop diagram of the housing platform.

Parameters representing the operational environment

The variables of feedback loops are all endogenous by nature: their dynamics is defined by the inner dynamic of a system. In a system, also exogenous variables are needed. When formulating the hypothesis of the system, three critical parameters determining the conditions of the housing platform were found. These exogenous variables are *residential plot market size*, *apartment seeker market size,* and *platform initial savings*. The parameters are rounded with a black line in Figure 13. Later, the scenarios to be simulated are constructed based on the variation of these parameters.

Strategic parameters

What are the strategic decisions needed? The dynamic hypothesis suggests that there are four main strategic variables here (underlined grey variables in Figure 13). These four variables are optimized under different circumstances in order to get insights for platform policy design. The first strategic parameter is a *matchmaking fee*. This is a certain fee that is added to the apartment's selling price and is charged from the apartment seeker when the transaction is executed. Increase in matchmaking fee adds profit per single sold apartment, but decreases the attractiveness for apartment seekers, since the total price of apartment increases. The second one is *developer reward* that is paid for landowners in order to attract them to add their residential plot to the platform. However, developer reward decreases the savings percent for apartment seekers. The third strategic variable is the *initial size of the apartment library*. The bigger the number the apartments, the better the library serves varying preferences of apartment seekers. The better library also increases the amount of possible residential plots, since it enables more variation in designing houses for a specific residential plot. The downside here is that developing a wider library costs more money. The last strategic decision to consider is *platform initial quality*. How much is it reasonable to invest in filter quality and user experience? The quality affects straight to a matchmaking decision, but it also costs money.

The goal of the optimization – finance, income, and costs

Due to the viewpoint of the platform owner, financial success was defined for the goal of the optimization. Financial resources (green variable in Figure 13) are defined by three parameters. The income consists of sold apartments (matches) and the matchmaking fee per single apartment, that are multiplied. The costs of the platform are related to the number of users (both sides), matches, and invests in platform quality and library. Besides the initial investments in quality and library, also keeping up the desired level costs money annually.

During the modeling process, it became clear that the costs of the platform are not affecting remarkably to the dynamics of the system. For that reason, costs are excluded from the final model (see chapter 4 for more information).

Monetization and subsidizing

How does the monetization work? The central assumption behind the whole platform business idea is that with the apartment library and modular designing, the opportunity to choose from tens or even hundreds of apartments is superior compared to competitors' offering. If the apartment price is also lower compared to similar apartments, there is no lack of eager apartment seekers. The platform is founded on the premise that if the apartment offering is attractive enough (including aspects of quality, price, and user experience), it takes only a few weeks to achieve a booking level of 95 – 100 % of apartments. No marketing is needed (apart from the launch campaign), but matches emerge with natural demand – offering pair.

Residential plots are as well the critical resource. For platform success, the sufficient number of residential plots (i.e. locations) is needed for apartment seeker attraction. Unfortunately, there are few plots with reasonable location free for sale. Usually, the residential plots are prepared for housing development by the urban planning process. Already during this process (or even before the urban planning process starts), the executor of housing development is selected. Thus, there are not many free residential plots, just waiting to be added to the housing platform.

How to overcome this challenge of residential plots? There are two central answers here. The first is subsidizing: a certain level of development reward is given to all landowners that add their residential plot to the platform. This can vary from zero to over 10 percent of the residential plot's value. The other aspect is the novelty of a platform. Currently, there are no similar options available to the author's knowledge. The possibility to interact straight with end customers and to just upload the plot to the platform and see what happens may attract landowners. With the platform, the demand for some residential plot is easily examined, without any negotiation round with several developers.

Reduction of friction

It is essential to reduce friction from all sides participating in the platform. From the viewpoint of apartment seekers, this means that the user experience and user interface are smooth and pleasant, and the matchmaking filter is working reasonably well. For landowners, uploading the residential plot to the platform should be very easy in order to get them to try a new way of developing their land property. However, this is a bit controversial issue. For maintaining the quality of plot offerings, curating is needed. In practice, landowners could easily suggest their residential plots to the platform curator, and if the plot suits to the platform, it is uploaded to the platform. Third-party innovators are the third segment to be considered. When the attraction of third-party developers emerges, it is critical that there is not significant friction to actually join the platform ecosystem. The frictionless experience is based on the mindset behind the platform. Concrete activities are related to platform governance, architecture, and application program interfaces (APIs).

3.5.3. Formulation of a simulation model

After defining the dynamic hypothesis, it is further developed into a formal simulation model. This model is also divided into three parts based on different sectors of a system. Stock and flow diagram is presented in Figure 14, Figure 15 and Figure 16. Strategic parameters are marked with a yellow background and environmental parameters with a green background. The parameters with a grey background are exogenous parameters that are fixed to a specific value.

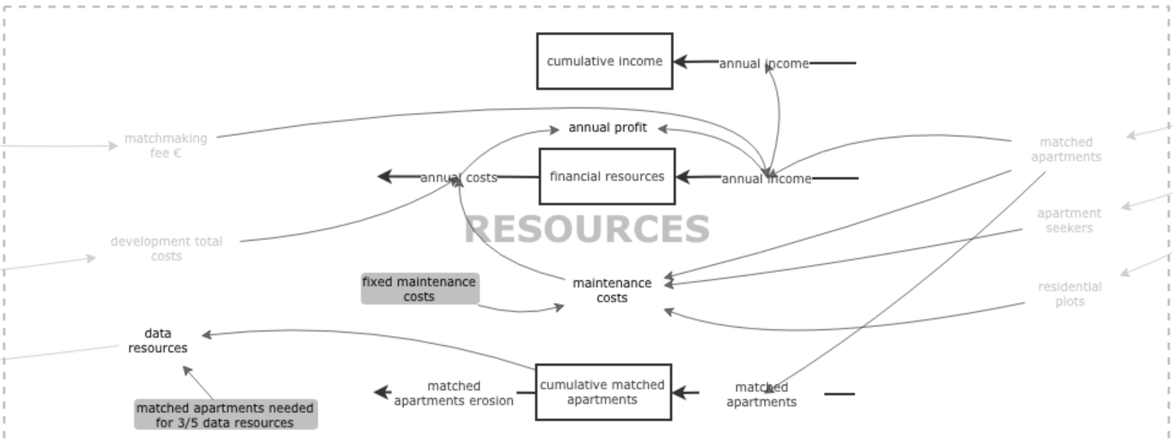

Figure 14. Stock and flow diagram, resource sector.

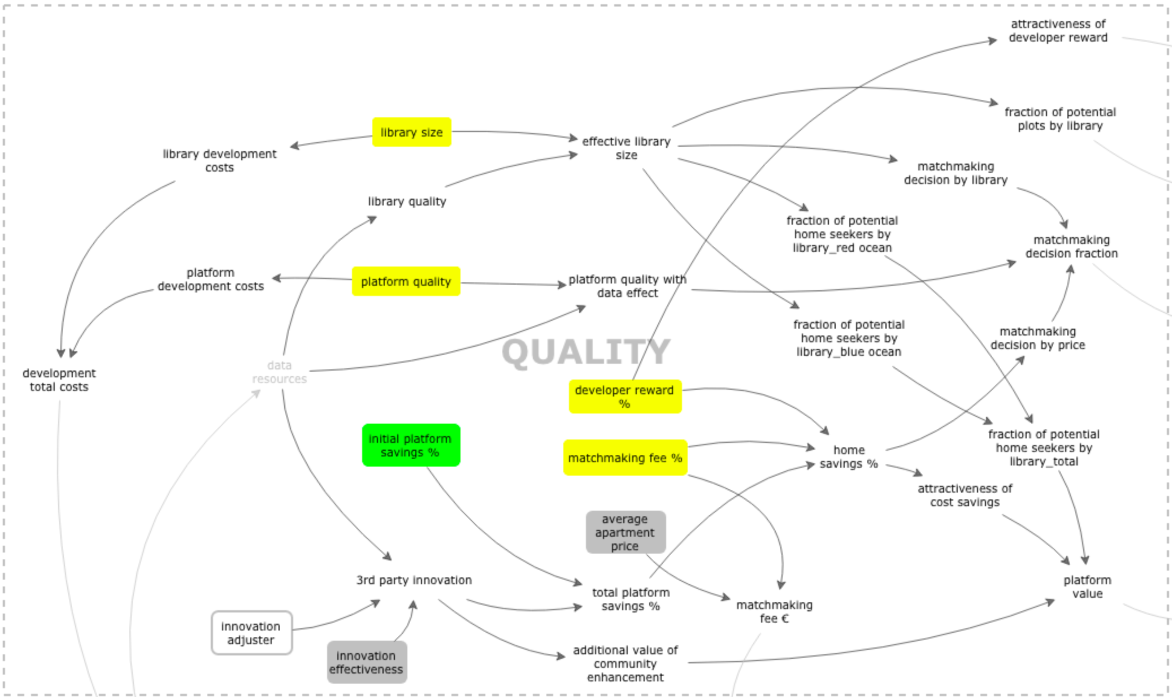

Figure 15. Stock and flow diagram, quality sector.

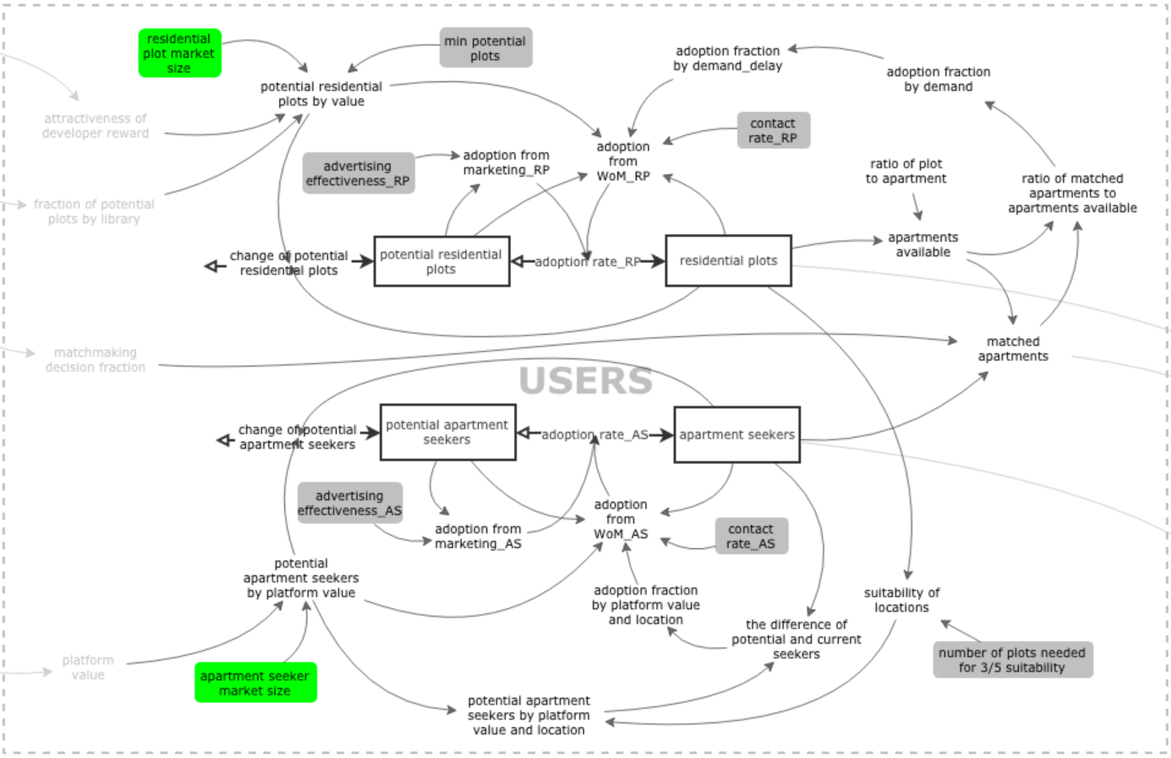

Figure 16. Stock and flow diagram, user sector.

The model imitates the markets of the capital area of Finland loosely: annual apartment seeker market size is 10000 in maximum, and there are at most 50 residential plots available for the platform. When speaking about apartment seekers, it is the number of new apartments sold per year. Thus, apartment seekers are the ones that will occupy a new apartment that particular year. The speculative what-if-we-moved-to-somewhere -cases are not included here. This explains the relatively small number of apartment seekers.

Four types of parameters

There are two basic types of parameters in a model. The first type is the endogenous parameter. These parameter's dynamic is dependent solely on the inner dynamics of the system. Another type is called an exogenous parameter. The value of the exogenous parameter is not dependent on the system, but it is determined by the system modeler. The three types of exogenous parameters are *strategic*, *operational environment*, and *fixed parameters*. All these exogenous parameters are presented in Table 9. A complete list of all parameters included in the model with their equations is presented in Appendix 1.

Exogenous parameter	**Parameter value and unit**	**Basis**
STRATEGIC		
matchmaking fee	0...100 % of the apartment price	In practice, the maximum value is at maximum equal to the platform saving percent. Otherwise, it would lead to higher prices compared to competitors and thus for platform failure.
developer reward	0...5 % of the apartment price	The reward is given to a landowner as a subsidy to increase attractiveness. Developer reward varies between 0 and 5 % of the total apartment price. When converted to the percentual change of plot value, the range is approximately from 0 to 15 %.
library initial size	0...500 apartments	This range is estimated to be feasible with the supervisor from the commissioned company. Because all the apartments cannot be used in every plot, the effective library size is smaller. This parameter was excluded from the optimizable parameters of the final simulations and fixed to its maximum value (500). See chapter 4.2.3 for details.
platform initial quality	0...0.8 (unitless)	The initial value of platform quality affects matchmaking fraction. The max value of platform quality is 1.0, and the missing 0.2 can be achieved by data. This parameter was excluded from the optimizable parameters of the final simulations and fixed to its maximum value (0.8). See chapter 4.2.4 for details.
ENVIRONMENT		

residential plot market size	5 / 10 / 20 / 50 residential plots per year	The parameter is varied with different scenarios. The scale is defined in co-operation with the commissioned company.
apartment seeker market size	2000 / 5000 / 10000 apartment seekers per year	The parameter is varied with different scenarios. The scale is defined in co-operation with the commissioned company.
initial platform savings	2 / 5 / 10 %	The parameter is varied with different scenarios. The scale is defined in co-operation with the commissioned company.
FIXED		
average apartment price	300 000 €	Based on market knowledge in the commissioned organization. Included in sensitivity analysis.
minimum number of potential plots	2 plots	There are at least two plots on a platform. Part of the platform owner's other projects can be easily added to a platform.
fixed maintenance costs	100 000 €/year	The minimum base cost of the platform. Besides, annual costs occur based on different parameters. This parameter was excluded from the final simulations. See chapter 4 for details.
max innovation effectiveness	0.2 (unitless)	Third-party innovation is related to data resources. When innovation reaches its maximum value, there is (a) additional 10% savings in platform cost and (b) a 20% increase in platform value. The increase in platform value increases the number of potential apartment seekers. Sensitivity analysis was made for evaluating the impact of alternative assumptions.
advertising effectiveness, apartment seekers	0.02 (unitless)	The value is defined in co-operation with the commissioned company, and sensitivity tested for evaluating the impact of alternative assumptions.
advertising effectiveness, residential plots	0.02 (unitless)	- // - (same as above)
contact rate, apartment seekers	100 contacts / year	- // - (same as above)
contact rate, residential plots	10 contacts / year	- // - (same as above)
matched apartments needed for 3/5 data resources	5000 apartments	With the cumulative number of 5000 matched apartments, data resources are approximately 0.6 (the value of data resource varies between 0 and 1). With 15000 cumulative matches the value of data resource is 0.95. Included in the sensitivity analysis.
number of plots needed for 3/5 suitability	50 plots	With 50 plots on a platform, the suitability fraction based on plot locations is around 0.6 (i.e. 60 % of apartment seekers find a plot that attracts them). With 10 plots, the suitability fraction is 0.18. Included in the sensitivity analysis.

Table 9. Exogenous parameters and their values of the system dynamic model.

Scenarios

Scenarios are based on different value combinations of exogenous environment parameters. Two of the three parameters are the number of market sides, and the third one is the initial savings of a platform.

The first parameter of the market side is a *residential plot market size*. Since there is not a pool of ready-to-develop residential plots available, it is difficult to estimate the actual market size and attractiveness of a platform. Therefore, the number of plots is varied. The range varies from 5 to 50 plots. This estimation is based on a rough number of 100 residential plots built each year in the Helsinki area. The imaginable maximum market size of the platform would hence be 50 percent of total markets.

Apartment seeker market size is another market side parameter. The value of this parameter is varied in three levels: 2000, 5000, and 10000 apartment seekers. Variation of both market sides changes the critical side of the platform and thus may give insights for different situations.

Platform initial savings have three different levels: the smallest is -2%, the middle is -5%, and the largest saving is -10%. The level of initial savings tells how much the new way of organizing the housing development process saves money. The saved money is then divided into three parts: apartment seekers (cheaper apartments), landowners (developer reward for adding attraction), and for platform owner (matchmaking fee). The values of initial savings were defined in co-operation with the company, and they represent a reasonable range of possible savings.

The basic matrix is developed by combining market sides together (Table 10). This generates 12 different scenarios. This basic matric is then included into another matrix that variates third party innovation and platform initial savings percent (Table 11). The matrix of matrices includes six different scenarios. The objective of varying third-party innovation is to analyze what is the effect of activating the innovation platform, or is there any difference? In a model, third-party innovation is related to the cumulative data resources. The hypothesis is that gathered data represents the market share and, thus, the attractiveness of a platform to third parties. This ecosystem innovation is not varied with simulations; only it either is or not.

Basic matrix	5 plots	10 plots	20 plots	50 plots
2000 apartment seekers				
5000 apartment seekers				
10000 apartment seekers				

Table 10. A basic matrix with twelve scenarios.

Matrix of matrices	2 % savings	5 % savings	10 % savings
no third-party innovation	Basic matrix	Basic matrix	Basic matrix
third-party innovation included	Basic matrix	Basic matrix	Basic matrix

Table 11. Matrix of matrices: six conditions for the base matrix.

With simulation, the goal of the optimization initially had two options: financial resources and cumulative income. In financial resources, both the income and costs are involved: financial resource is a cumulative result of annual incomes and costs. The other goal of optimization is cumulative income. As the name tells, this includes only annual incomes added together.

When comparing the scenarios optimized for financial resources to cumulative income, there was no significant difference in the dynamics of the platform. Obviously, when cumulative income is optimized, the financial result is more significant since there is no need for caring costs. On the contrary, including the costs does not change the dynamics of the model, but the results are approximately 10 % lower. However, the dynamic seems to remain relatively the same. In addition, the estimation of costs is highly speculative, and concentration for income may give better insights for decision-making. Therefore, all the simulations were decided to optimize for maximizing the cumulative income. With cumulative income, the costs of platform development (both library and platform quality) and the maintenance costs of the platform are not included.

3.5.4. Testing

Testing and evaluation of the model is a constant process. After the first dynamic hypotheses, also the first sketches of the simulation model were constructed. Simulations were used to develop the hypothesis and parameter values. Values and equations of the parameters were determined with professionals of the commissioned company.

All the fixed, exogenous parameters were tested with sensitivity analysis. The only exception was the parameter of minimum potential plots: because the value of this parameter is strongly controlled by the platform owner, there was no need for varying it. Other parameters were tested all at once (multivariate testing). For Monte Carlo simulation, a specific range and the standard deviation was defined to each parameter. The list of tested parameters with initial values and range is presented in Table 12.

Parameter	**Initial value and unit**	**Range**
average apartment price	300 000 €	200000 – 400000
max innovation effectiveness	0.2 (unitless)	0 – 0.2
advertising effectiveness, apartment seekers	0.02 (unitless)	0.005 – 0.02
advertising effectiveness, residential plots	0.02 (unitless)	0.005 – 0.02
contact rate, apartment seekers	100 contacts / year	25 - 175
contact rate, residential plots	10 contacts / year	2 - 18
matched apartments needed for 3/5 data resources	5000 apartments	2000 - 8000
number of plots needed for 3/5 suitability	50 plots	20 - 80

Table 12. Parameters included in the sensitivity analysis.

The sensitivity test was executed with the following specifications. Environmental conditions were: 10 % platform savings, 5000 apartment seeker market size, and 20 residential plot market size. In a test, a total of 500 runs were executed. Confidence regions were set to 50, 75 and 95 %. The values of the strategic parameters were based on the results of the simulation model: matchmaking fee 3.2 %, developer reward 1.1 %, initial library size 500 apartments, and platform initial quality 0.8 (see chapter 4).

Figure 17 presents the number of matched apartments with confidence bounds. With 50 % confidence, the dynamics of the model seem to remain relatively the same. With limit values, the dynamics change more significantly, especially reinforcing the growth of matches. The other Monte Carlo simulations representing cumulative income, residential plot market side, and apartment seeker market side are presented in Appendix 2.

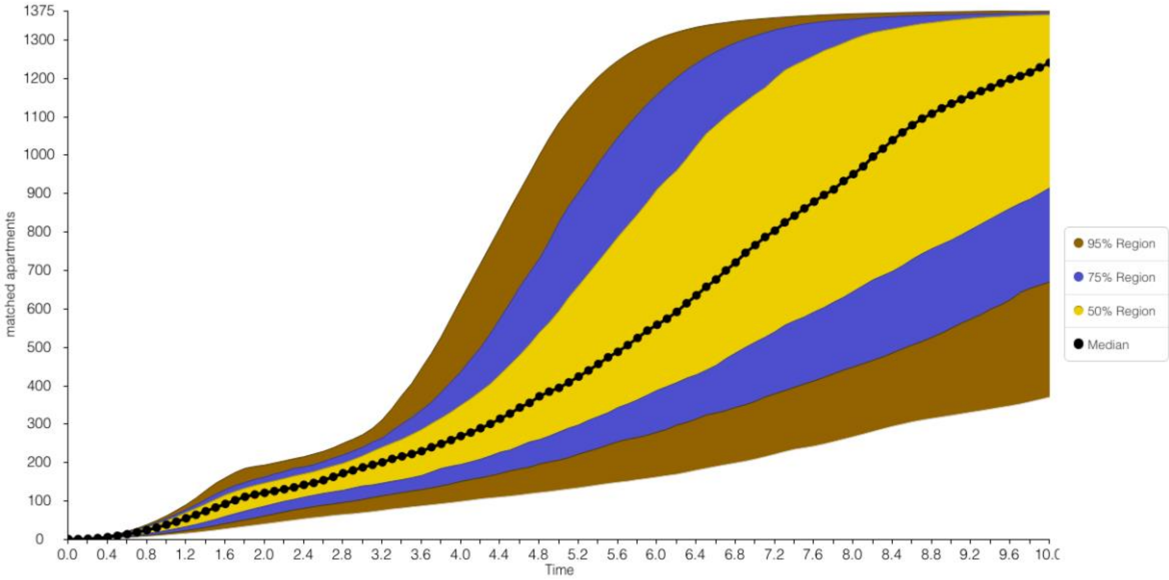

Figure 17. Monte Carlo simulation of matched apartments.

In the end, it is not possible to absolutely validate the model. However, the model was constructed in close co-operation with the supervisor from the commissioned company. Besides, two modeling professionals were consulted during the process. The overall validity and reliability of the research is elaborated in chapter 3.4.

4. THE RESULTS OF THE MODELING

In this chapter, the results are shown. Policy design and evaluation are discussed in the next chapter (chapter 5).

The simulations were executed with InsightMaker. The following specs were used: Simulation time was ten years with a 0.1-year time step, the number of random starts was 5, the maximum number of iterations was 1000, and the step reduction factor was 0.01. In order to get more precise results with a reasonable time, the approximate optimum level was first defined. After that, the minimum and maximum boundaries of strategic parameters were set to relatively close to that approximate optimum. For instance, if the optimal value of matchmaking fee was 5 %, the boundaries of the parameter were defined from 0 to 8 %. Based on testing with different specs and manual simulation exploration, the margin of error is estimated to be +-0.1% with matchmaking fee and developer reward, +-10 apartments in the apartment library, and +-0.01 in platform quality. Simulation results are shown in Table 13, Table 14, and Table 15.

SIMULATION RESULTS 1/3*		5 plots		10 plots		20 plots		50 plots	
Initial savings: 2%		A**	B	A	B	A	B	A	B
2000	matchmaking fee	1,0 %	1,0 %	1,0 %	1,0 %	1,0 %	1,0 %	1,0 %	1,0 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
	cumulative income M€	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3
5000	matchmaking fee	1,0 %	0,9 %	1,0 %	0,9 %	1,0 %	0,9 %	1,0 %	0,9 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
	cumulative income M€	0,6	0,7	0,6	0,7	0,6	0,7	0,6	0,7
10000	matchmaking fee	1,1 %	0,7 %	1,1 %	0,7 %	1,1 %	0,7 %	1,1 %	0,7 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
	cumulative income M€	1,0	1,6	1,0	1,6	1,0	1,6	1,0	1,6

*platform quality = 0.8, library size = 500

**A = initial platform savings only, B = 3rd party innovation included

Table 13. Simulation results 1/3.

SIMULATION RESULTS 2/3*		5 plots		10 plots		20 plots		50 plots	
Initial savings: 5 %		A**	B	A	B	A	B	A	B
2000	matchmaking fee	1,9 %	1,9 %	2,0 %	2,0 %	1,9 %	1,9 %	2,0 %	2,0 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
	cumulative income M€	2,4	2,9	2,4	2,8	2,4	2,9	2,4	2,9
5000	matchmaking fee	1,9 %	2,1 %	1,9 %	2,1 %	1,9 %	1,3 %	1,2 %	1,0 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,3 %	0,2 %	0,3 %
	cumulative income M€	5,2	7,8	5,2	7,8	5,2	8,6	5,3	11,8

10000	matchmaking fee	1,5 %	2,5 %	1,5 %	2,0 %	1,4 %	1,7 %	1,2 %	1,7 %
	developer reward	0,3 %	0,3 %	0,4 %	0,6 %	0,6 %	0,9 %	0,5 %	0,9 %
	cumulative income M€	9,3	12,7	11,8	17,0	16,0	25,0	30,2	49,3

*platform quality = 0.8, library size = 500

**A = initial platform savings only, B = 3rd party innovation included

Table 14. Simulation results 2/3.

SIMULATION RESULTS 3/3*		5 plots		10 plots		20 plots		50 plots	
Initial savings: 10%		A**	B	A	B	A	B	A	B
2000	matchmaking fee	5,2 %	5,6 %	5,2 %	5,6 %	5,2 %	5,6 %	5,2 %	5,6 %
	developer reward	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
	cumulative income M€	11,4	12,7	11,4	12,7	11,4	12,7	11,4	12,7
5000	matchmaking fee	4,5 %	5,1 %	3,9 %	4,7 %	3,2 %	4,3 %	3,3 %	4,0 %
	developer reward	0,5 %	0,8 %	0,9 %	1,0 %	1,1 %	1,4 %	1,0 %	1,3 %
	cumulative income M€	26,7	32,2	34,6	45,0	48,2	67,2	78,0	124,3
10000	matchmaking fee	5,5 %	6,1 %	5,2 %	5,8 %	4,9 %	5,5 %	4,7 %	5,3 %
	developer reward	1,1 %	1,2 %	1,3 %	1,4 %	1,5 %	1,6 %	1,6 %	1,7 %
	cumulative income M€	44,2	46,6	68,8	74,1	115,3	125,3	243,3	265,0

*platform quality = 0.8, library size = 500

**A = initial platform savings only, B = 3rd party innovation included

Table 15. Simulation results 3/3.

In each scenario, cumulative income was maximized. In other words, platform quality and library size parameters have been fixed to their maximum value (platform quality = 0.8, library size = 500). The equations of both financial stocks are:

$$\textit{cumulative income} = \sum[\textit{annual income}]$$

$$\textit{financial resources} = \sum([\textit{annual income}]-[\textit{annual costs}])$$

Why not include the cost side for the optimization? First, it appeared that in every scenario, library size was optimized to the maximum value of 500 apartments. This clearly tells that the benefits of the library are superior to the cost of the library. Because the optimal value is already known, there is no need for including that into final scenarios. It is almost the same with platform quality. This parameter is varying between 0.7 and 0.8, thus not changing remarkably the dynamics of the system. Of course, cumulative income generates higher financial value, and there are some economies of scale (i.e., when user sides and platform savings increase, also increases the difference between cumulative income and financial resources). However, this phenomenon is not affecting remarkably to the dynamics. Figure 18 visualizes this difference.

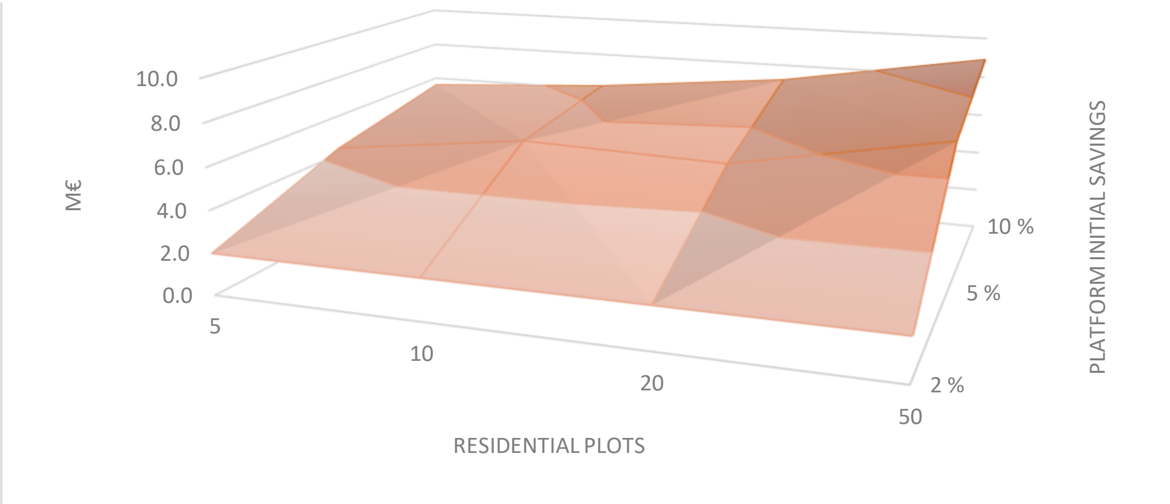

Figure 18. Difference between cumulative income and financial resources. Apartment seeker market size = 10000, transaction platform.

The results of the modeling are divided into three sub-chapters. The first chapter shows the results of the operational environment; the second the results linked to strategic decisions, and the last sub-chapter shows the effect of third-party innovation.

4.1. Environmental conditions

The three variables representing the operational environment are *apartment seeker market size*, *residential plot market size*, and *platform initial savings*. The first two variables define the potential maximum on both market sides, but they are not affecting straightly to the actual number of users on a platform. The equations of apartment seekers are as follows:

potential apartment seekers by platform value = [apartment seeker market size][platform value],*

platform value = [fraction of potential home seekers by library_total][attractiveness of cost savings]*[additional value of community enhancement],* and

apartment seeker market side varies between 2000, 5000 and 10000

In the model, platform value varies between 0 and 1+, depending on the library quality, cost savings, and additional third-party innovation. Therefore, the number of potential apartment seekers can exceed the market size. This is based on the premise that if, for instance, the price of the apartments would fall to half of the competitor price, the possible market side would increase significantly, attracting totally new markets (such as the seekers of used apartments).

The other environment variable, residential plot market size affects to the system in a following way:

potential residential plots by value = [min potential plots]+([residential plot market size]-[min potential plots])[fraction of potential plots by library]*[attractiveness of developer reward],*
min potential plots = 2,
attractiveness of developer reward = 1-e^-([developer reward %]/0.01),
fraction of potential plots by library = 1-e^-([effective library size]/50),
residential plot market size varies between 5, 10, 20 and 50 plots

With residential plot side, the environment variable sets the absolute maximum of the market size. In the model, it is assumed that there are at minimum two plots on a platform. This premise is argued by the fact that the platform owner has a construction business and is already building apartment buildings. These projects can well be uploaded to the platform. Developer reward and library size have a value between 0 and 1. The functions of these variables are called a cumulative distribution function. It increases strongly from the beginning, but then slows down and achieves the upper limit value in infinity.

Based on simulations, approximately a minimum of 5000 apartment seekers, 10 residential plots, and 5 % savings are needed for a successful business. Of course, if platform initial savings are close to the max value, even 2000 apartment seekers are enough for a successful business. What about the sufficient level of cumulative income? In this research, it is estimated that at minimum, 1 million € income is needed per year for sustainable business. This sums up to 10 M€ in the 10-year simulation time.

4.2. Optimal strategic decisions in different scenarios

There is a total of four strategic parameters that need to be optimized for maximum performance. In this chapter, the optimal results of these variables are shown. There are a total of four different matrices, but here just one is shown. This is because the dynamic of the model remains the same, even if there is a variation in the optimizable variable (financial resource or cumulative income) or third-party innovation (included or not).

4.2.1. Matchmaking fee

The first and maybe most crucial strategic decision is about **matchmaking fee**. It affects in many ways to platform success: home seeker side attractiveness, matchmaking decision, and the number of plots in the platform. The matchmaking fee has a positive correlation with platform savings and a negative correlation with plot amount. Interestingly, there is no direct connection between the apartment seeker market size and matchmaking fee. With 2 % savings, the matchmaking fee remains quite the same level. With 5% initial savings, matchmaking fee decreases when apartment seekers increase. With 10 % savings, the optimal matchmaking fee is U-shaped, being smallest with 5000 apartment seekers. The optimal level of the fee is roughly half of the total savings, and the level varies roughly between 1 and 6 % (see Figure 19). The percent describes the amount of money that apartment seekers pay with the apartment to the platform owner. The percentage is calculated out of the average home price.

Figure 19. Optimized matchmaking fee (20 plots, transaction platform).

The optimal level of the fee depends on the balance of the two market sides. If decreasing the matchmaking fee increases the number of matches, the optimal level is optimized lower. On the other hand, if there is no potential in adding matches, the level of matchmaking fee is optimized to higher. The dynamics of Figure 19 are dependent on the relationship of apartment seekers and residential plots (two feedback loops: cross-side network effect R1 and congestion of residential plots B1). In the model, apartment seekers on a platform control the number of residential plots on a platform with the following equations:

ratio of matched apartments to apartments available = [matched apartments]/[apartments available],

apartments available = [residential plots][ratio of plot to apartment],*

ratio of plot to apartment = 100, and

matched apartment = IfThenElse([apartment seekers][matchmaking decision fraction]>[apartments available],[apartments available],[apartment seekers]*[matchmaking decision fraction])*

In other words, the attractiveness of the platform for plot owners depends on the balance between apartment offering and matched apartments. Half of the apartments available are needed to be sold in order to maintain the adoption fraction in level zero. If all the apartments that are uploaded to the platform are sold, the platform will attract all the possible residential plots. However, if only a little fraction of apartments available are sold, the platform is less attractive for plot owners. This leads to a decrease of plots in a platform.

Because of the nature of the cross-side network effect, the interaction also works the other way around. In the model, residential plots on a platform control the number of apartment seekers on a platform with the following equations:

*potential apartment seekers by platform value and location = [potential apartment seekers by platform value] * [suitability of locations],*

suitability of locations = 1-e^-([residential plots]/[number of plots needed for 3/5 suitability]), and

number of plots needed for 3/5 suitability = 50

The equations above suggest that enough residential plots are needed for matching the locations that potential apartment seekers are preferring. If, for instance, there are 50 residential plots on a platform, about 60 % of apartment seekers will find a suitable location for themselves. However, with just a couple of residential plots, the suitability fraction is only about one-tenth.

With 2000 apartment seeker market size and 10 % platform savings, matchmaking fee is optimized to a relatively high level. In this scenario, decreasing matchmaking fee would attract more potential apartment seekers and increase the matchmaking fraction. However, the total number of matches would not increase significantly because the reinforcing cross-side network effect loop R1 does not start properly.

With 5000 apartment seekers market side and 10 % platform savings, the optimal matchmaking fee level is significantly lower than with other apartment seeker market sides. In this scenario, the matchmaking fee is decreased for supporting the reinforcing feedback loop R1. Increasing the attractiveness for apartment seekers and the matchmaking fraction leverages the ratio of matched apartments to available apartments and thus increases the attractiveness for the other market side. With more plots on a platform, more apartment seekers appear, and the reinforcing feedback loop is working strong.

In a scenario with 10000 apartment seeker market side and 10 % platform savings, matchmaking fee is again at a relatively high level. Here, all the available apartments are already matched, so there is no incentive for increasing the apartment seeker market side. Instead, it is reasonable, from the platform owner viewpoint, to maximize the profit for every single match by increasing the matchmaking fee.

4.2.2. Developer reward

The second strategic variable that also has percentages is **developer reward**. Subsidizing the landowners is essential because of limited plot resources. The effect of developer reward is relatively straight forward: the bigger the reward, the higher the attractiveness of landowners. This attractiveness (value between 0 and 1) is then multiplied with residential plot market size and fraction of potential plots by the library. The equation is presented in chapter 4.1. Besides increasing the attractiveness of landowners, developer reward also decreases the number of apartment seekers by diminishing the total platform savings (balancing feedback loop B1 in Figure 13).

The reward is a percent of the total price of an average apartment. Since the plot price is much less than the total price of the apartment, a two percent reward calculated from the total price of the apartment means a nearly 10 % increase in earnings for the landowner. The developer fee has a positive correlation in all the variables: savings, apartment seekers, and plot amount. The optimal level is roughly one-tenth of total savings, and it varies between 0 and 1.7 % (see Figure 20).

Interestingly, that developer reward stays at zero with 2000 apartment seeker and all plot numbers. Relatively high platform savings and apartment seeker market size are needed for paying developer reward. If the apartment seeker market size is small, it is not reasonable to pay developer reward at all since there is no demand for more plots. In the model, there are at minimum two plots on a platform: this premise affects a lot to developer reward.

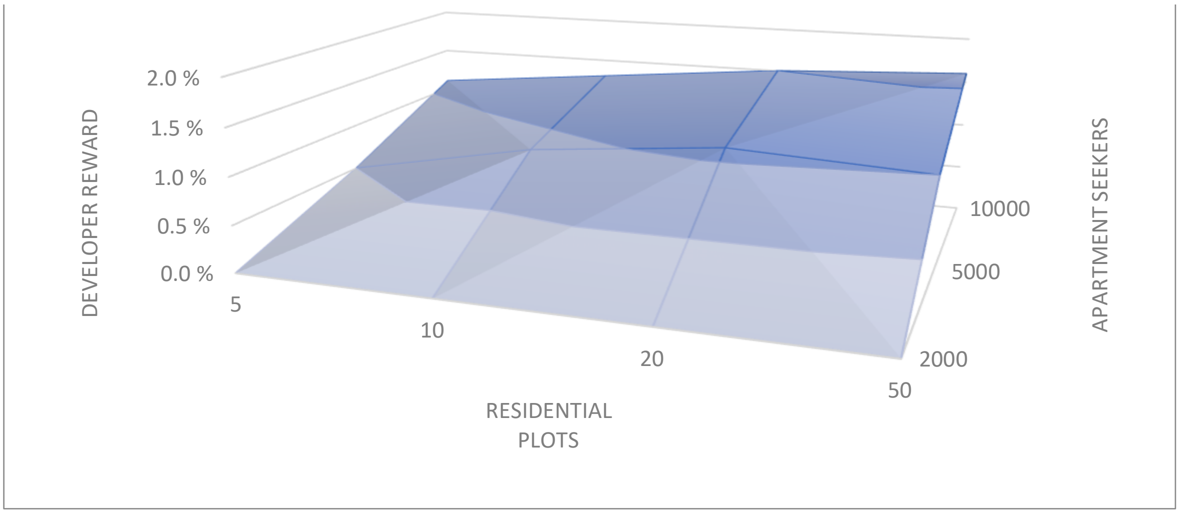

Figure 20. Optimized developer reward (10 % platform initial savings, transaction platform).

4.2.3. The initial apartment library size

The third strategic resource is **the initial size of the apartment library**. Housing library is the most critical strategic resource in gaining competitive advantage in three ways: (1) it adds potential home deals, (2) adds potential residential plots, and (3) supports the decision making i.e. matchmaking. Library size, together with library quality, form a variable named effective library size. The equations are as follows:

effective library size = 0.4[library size]*[library quality],*

*library quality = 0.8+[data resources]*0.2,* and

library size varies between 0 and 500

The effective library size is scaled down to a maximum of 200. This is because not all of the apartments in a library can be used in every residential plot. Library quality varies between 0 and 1, and the initial value is 0.8. When matches are generated, also data resources appear. This can increase the library quality to 1, which means that there is no diminishing of the effective library size caused by library quality.

The size of the library is from zero to 500 apartments, and the costs of the library are as follows: the designing of the apartment is 1000 € (this is an initial cost), and maintaining and refreshing the apartment costs 100 € per year (continuous costs). The costs are based on real-world prices of actual library development. As the costs are relatively low compared to annual incomes, the number of apartments in the library is optimized to a maximum value in all scenarios (500 apartment options). In other words, the benefits of the library easily outweigh the costs. For simplicity, this parameter was not optimized in scenarios, but instead, it was fixed to its maximum value.

4.2.4. Platform initial quality

The fourth strategic decision to be optimized is **platform initial quality**. Platform quality influences matchmaking decisions and is another critical enabler of the business model. Platform quality involves UX, matchmaking filter quality, and other critical features. The maximum level of platform quality is 1, which means that there is no friction in matchmaking. However, with development investments, it is only possible to achieve a value of 0.8. The lacking 20% of the platform quality is dependent on the cumulative data resources. The equations related to platform quality are:

*platform quality with data effect = [platform quality]+[data resources]*0.2,*

platform quality varies between 0 and 0.8, and *data resources* varies between 0 and 1

The optimal value rises with a rising plot amount and rising savings (positive correlation in both cases). The value varies between 0.7 and 0.8 (max initial value=0.8 + data effect 0.2). Overall, platform development costs are minor to benefits, as with initial library size. For simplifying simulations, this parameter is fixed to its maximum value (0.8).

4.3. The effect of third-party innovation

Third-party innovation (reinforcing loop R4 in Figure 13), was included in the model in order to analyze the difference between transaction and hybrid platform. In the model, third-party innovation adds the total platform savings and also gives added value by enhancing the community. These effects lead to a higher number of potential apartment seekers and greater matchmaking fraction. Third-party innovation varies between 0 and 0.2, and the equations related to it are:

*total platform savings = [initial platform savings %]+[3rd party innovation]*0.5,*
additional value of community enhancement = 1+[3rd party innovation],
3rd party innovation = [data resources][max innovation effectiveness]*[innovation adjuster],*
max innovation effectiveness = 0.2,
data resources vary between 0 and 1, and
innovation adjuster controls whether third-party innovation is included or not

Third-party innovation affects the model two ways: it (1) boosts the cross-side network effect between platform users and (2) adds platform savings and, therefore, financial resources of the platform owner by enabling bigger matchmaking fee. As the equations reveal, third-party innovation can increase the total platform savings at a maximum of 10%. This requires data resources to achieve the maximum value of 1. Additional value is between 1 and 1.2, and it is a multiplier of the platform value.

Third-party innovation influences positively in all scenarios. Usually, the increasing number of plots increases also the power of innovation. The dynamics of ecosystem innovation is presented in Figure 21. The figure shows the percentual growth of cumulative income with different scenarios. The dynamics of the hybrid platform can be explained through the two ways that innovation affects: boosting cross-side network effect (R1, see Figure 13), and adding total savings. In every scenario, innovation is adding the platform savings and, thus, the cumulative income of the platform owner. The most significant potential lies in the other connection: the core question is whether third-party innovation boosts cross-side network effect or not.

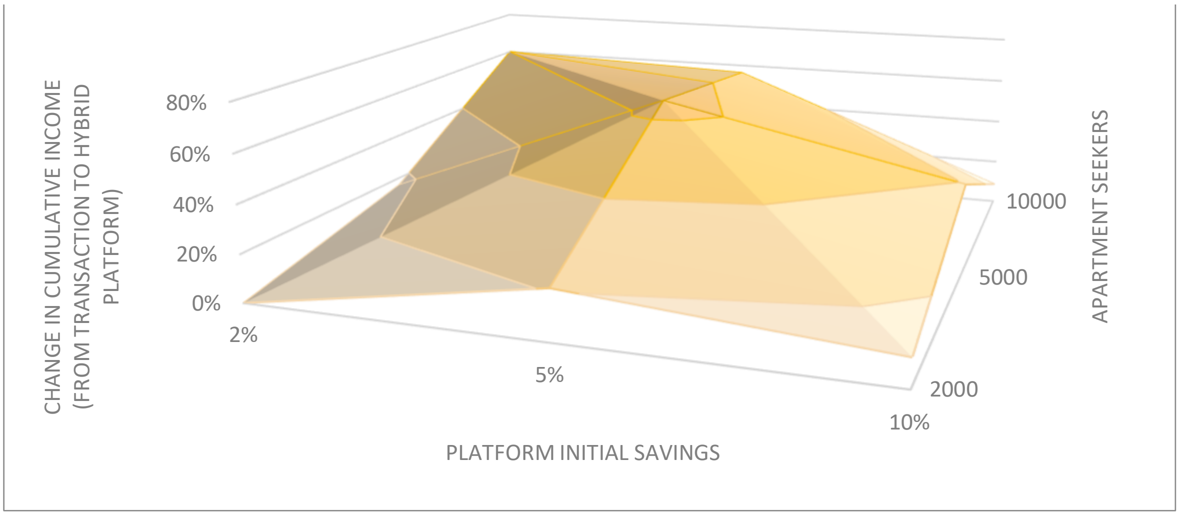

Figure 21. The effect of third-party innovation on cumulative income (residential plot market size = 20).

The highest benefit from innovation is achieved with 5 % initial savings and 500 apartment seekers (65 % increase in cumulative income, see Figure 21). With this scenario, innovation adds the number of apartment seekers, and there are also apartments available for these new platform users. The cross-side network effect is further reinforced with decreasing matchmaking fee and thus increasing the number of apartment seekers.

On the contrary, in the scenario of 10 % platform savings and 10000 apartment seekers, the effect of innovation is less than 10 % (Figure 21). This indicates that the benefit of third-party innovation is limited to additional platform savings. All the apartments available are already matched, and the market is saturated, and thus adding apartment seeker market size does not feed the reinforcing loop R1. Therefore, in this scenario, the number of matches does not increase. Logically, the matchmaking fee is increased in this scenario for getting the best financial benefit.

5. DISCUSSION AND CONCLUSIONS

5.1. Guidelines for housing platform

The main question of the research was: How to reshape the housing development with platform strategy? Overall, based on the system dynamics modeling process, it can be said that the business idea of the housing platform can be realizable and successful. However, sufficient environmental conditions are needed with correct strategic decisions. In this chapter, the platform strategy of the housing platform is discussed, and the answer to the research problem is given. Also, limitations and future topics are emphasized.

Initially, financial costs were included in the simulation model. However, during the research process, it appeared that the costs caused by library size and platform development did not affect the dynamics of the system. Simulation results remained relatively the same whether the optimizable variable was financial resources (including both costs and incomes) or cumulative income (only income included). Even if the expenses were taken account, the library size and platform quality were optimized close to the maximum value. This indicates that the benefits of developing the library and platform are superior to the financial drawbacks.

For the reasons explained above, costs were excluded from the simulation model, and only the income side was examined. Because of that choice, the library size and the platform quality were fixed to their maximum values: when not taking account of the costs, the strategic decisions that need investments are naturally maximized. In Table 16, the strategic decisions are summed up with the most significant modeling results and practical implications.

Strategic decision	**The results of the modeling**	**Practical implications**
Matchmaking fee	+ positive correlation with <u>platform savings</u> + negative correlation with <u>residential plots</u> + nonlinear correlation with <u>apartment seekers</u>	Matchmaking fee affects negatively to the attractiveness of apartment seekers and to the matchmaking fraction. The optimal level of the fee depends on the balance of the two market sides. If there is a potential of increasing the market sides,

	+ the optimal level of the fee is roughly half of the total savings, and the level varies roughly between 1 and 6 %	matchmaking fee is decreased in order to attract more users (especially with 10% savings and 5000 seekers). However, if all the market is already saturated, it is reasonable to increase the matchmaking fee for getting the best financial benefit.
Developer reward	+ positive correlation with platform savings, residential plots and apartment seekers + the optimal level is roughly one-tenth of total savings, and it varies between 0 and 1.7 %	Developer reward affects positively to residential plots (by increasing attractiveness), and negatively to apartment seekers and matchmaking fraction (by decreasing total savings). Relatively high platform savings and apartment seeker market size are needed for paying developer reward. If the apartment seeker market size is small (~2000), it is not reasonable to pay developer reward at all, since there is no demand for more plots. In the model, there are at minimum 2 plots on a platform: this premise affects a lot to developer reward.
Library size	(Not varied in scenarios. The number of apartments in the library is fixed to the maximum value of 500 in each scenario.)	Library size positively affects apartment seekers, residential plots, and matchmaking fraction. Library is the main strategic resource in creating additional value and achieving competitive advantage. The benefits of the library are easily superior to costs. Therefore, it is reasonable to maximize it.
Platform quality	(Not varied in scenarios. The platform quality is fixed to its maximum value of 0.8 in each scenario.)	Platform quality affects positively to the matchmaking fraction. A strategic enabler that is needed for successful business. Therefore, it is reasonable to maximize it in practically any scenario (the development costs are minor to benefits).
Third-party innovation (hybrid platform)	+ adds cumulative income 0...123 % (0...46.3 M€) depending on the scenario + the effect is strongest in the middle (~5000 apartment seekers, ~5 % platform savings) + number of plots increase the effect, but only with higher platforms savings + matchmaking fee is adjusted depending on the balance of two-sided markets	Third-party innovation (1) boosts the cross-side network effect between platform users and (2) adds platform savings and, therefore, financial resources of the platform owner. If there is a potential of increasing the market sides, the matchmaking fee is decreased in order to attract more users. However, if all the market is already saturated, it is reasonable to increase the matchmaking fee for achieving the best financial result.

Table 16. The results and practical implications of the strategic decisions.

5.1.1. Housing platform and environmental conditions

The fourth research question (RQ4) was: How does the operational environment influence on platform success? Based on modeling and simulations, three crucial parameters influencing platform success were found: *residential plot market size*, *apartment seeker market size,* and the *initial savings of the platform*. The influence of each separate parameter is quite simple, but when combining, complex, nonlinear dynamics appear. These dynamics are further considered with strategic parameters.

5.1.2. The strategic decisions for competitive advantage

Research question five (RQ5) was: What are the most critical strategic decisions needed for platform success? There is a total of four strategic parameters included in a model: *matchmaking fee, developer reward, library size,* and *platform initial quality*. The analysis of the simulation results addresses that both library size and platform quality are critical resources of competitive advantage. Platform quality influences straight to matchmaking fraction and is, therefore, part of every reinforcing feedback loop of the system (R1, R2, R3, and R4). The library is also a central source of the dynamic system. Besides, the expenses needed for developing these resources are minor to the benefits. Therefore, both of the parameters are optimized to almost maximum in every scenario. The strong emphasis on these valuable assets is crucial for platform success.

Matchmaking fee is the source of platform financing. Interestingly, it is a double-edged sword: increasing the fee gives more income per apartment but decreases the number of matched apartments. Matchmaking fee affects platform value and thus refines the number of potential users of the platform. In all scenarios, the matchmaking fee was stable. It would have been interesting to analyze the optimal level that changes over time. Presumably, it would be profitable to keep the matchmaking fee fairly low for feeding the cross-side network effect. When working correctly, the matchmaking fee could be returned to a financially optimal level.

It seems that the question of developer reward is much simpler. As Figure 20 reveals, the optimal level is correlating positively with both plots and apartment seekers. Also, there is a positive correlation with savings percent.

5.1.3. Transaction or hybrid platform?

Basically, rearranging the housing development process with a platform strategy is a fully transactional approach. The core question is: how to make a most efficient marketplace for different market sides, the ones who produce, and the others who consume.

The last research sub-question (RQ6) was related to platform types: What is the importance of ecosystem innovation to platform success? Ecosystem innovation is similar to third-party innovation and innovation platform aspect. Thus, the question could also be formulated this way: is there an incentive for the platform owner to develop the transaction platform towards a hybrid one? Based on the analysis, including the innovation platform aspect to the transaction platform is financially profitable. There is nonlinear dynamics with innovation, as Figure 21 shows. This dynamic is mainly related to different limit values of the system: if all the apartments available are already sold, there is not a significant change of adding apartment seekers on a platform or increasing matchmaking fraction.

However, opening up the platform to third parties is not that simple. External actors develop more complex connections to a platform. These connections are not restricted to this specific platform: since third parties aren’t locked to one platform, multihoming occurs. This multihoming creates connections also between platforms (Hilbolling 2019, 10). Thus, much governance and architectural issues are to be solved in order to empower the ecosystem innovation fully.

In a model, no friction of platform features is included. In reality, the questions of platform architecture and governance are critical for enabling the platform to act as an innovation platform. These include both mental attitudes and technical issues, such as API.

5.1.4. The lifecycle of the housing platform

Even though modeling has a time aspect, the picture that is revealed through system dynamics modeling quite static. The model used in this research does not take into account the maturing of a platform. Instead, it gives just a single view for a specific moment of the platform. In this chapter, the evolvement and maturing of a platform are considered.

In general, managing network effects is crucial for platform development and success. The critical aspect is how to empower the positive effects, and at the same time, reduce the negative ones? The state of the platform is not static, but it is continuously changing. Managers need to be aware of this change and be able to make the right decisions in a particular context.

Startup phase

For every platform business, the chicken or egg -problem needs to be solved. The critical question about multi-sided markets is how to attract either side of platform users if the other side is not yet included? For solving this challenge, multiple answers were found during the research process. Since the platform owner already has a construction business, it would be easy just to put some projects into the platform. When there are a couple of residential plots (it is, locations), the apartment seekers will come to check what is going on, what is this platform. The platform could also have a feature that enables apartment seekers to tag interesting locations or city districts. Tags would make the demand visible, and thus attract the landowners to upload their residential plots to the platform.

One interesting idea that arouses from the interview data was a *dreaming platform*. With it, people could use the platform as a toy for seeking their next home. Where would we like to live? In what kind of apartment? Which floor, where do the views open? What interior style suits for us? Do we want a vast, open space or several smaller bedrooms? What would be a price tag for our dream? This playing aspect could attract apartment seekers to sign in for the platform. Of course, in order to function, many investments to the platform should be made. This may be difficult in the beginning, since there is not yet any income from the platform.

Coming to existing markets with a new product is not easy. In order to succeed, a strong brand is needed. What helps here is that the company is already actually building houses, and it has a reputation as an innovative reformer of the construction industry (Arola 2017). With branding the platform as part of the broader company, it is easier to gain trust. In the model, marketing is considered to be stable. In reality, a broad advertising campaign would most probably be reasonable.

Last, the operation of the platform is built firmly on algorithmic, automated processes. Especially the modular design of residential plots is considered to be almost fully autonomous in the future. However, in the beginning, all the design work would be made by a human. This is reasonable because it reduces the initial investments: it is possible to examine hands-on if the business idea works or not. After there is a money stream coming in, it is easier to put money for development.

Growth phase

When time goes, and network effects start to affect, the number of both sides increases. This enables to develop further and automate the platform. After these couple of emerging years, it is also possible to expand to foreign countries. There is much information that can be transferred from one market area to another, but for instance, the housing regulation differs from country to country. Also, the curation of residential plots is still needed.

In Figure 22, the growth strategy is compared to the strategy of staying in a restricted market area. The figure presents a time series data of matched apartments with both scenarios. The basic scenario has 5 % platform savings, residential plot market size of 50 and apartment seeker market size of 10000. The figure reveals that the market is saturated in around eight years (the point of achieving the maximum level). The growth scenario has the same platform savings (5 %), but both market sides are increasing linearly from 50 plots and 10 000 apartment seekers to 500 plots and 100 000 apartment seekers in ten years (multiply by ten). As the figure indicates, the growth of market sides leads to the growth of matched apartments and thus higher income.

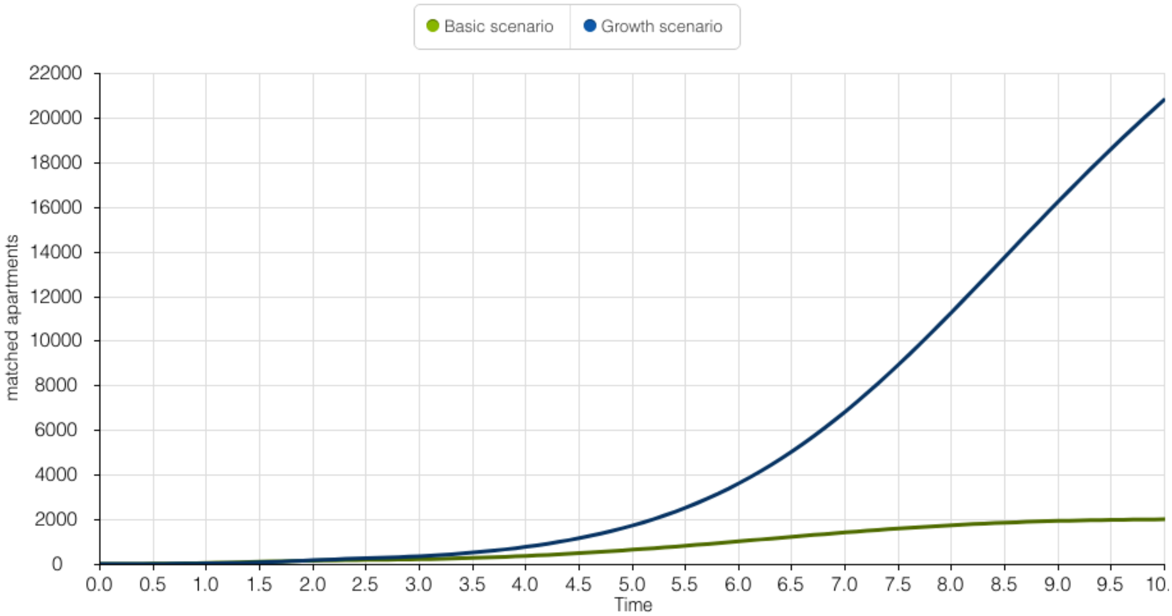

Figure 22. Limited markets compared to expanding markets. A time series of matched apartments.

Changing the market sides over time also influences the strategic parameters. With the basic scenario, matchmaking fee is optimized to 1.2 % and developer reward to 0.5 % (see Table 14). With growth scenario, matchmaking fee is optimized to 2.2 % and developer reward to 0.9 %. Increasing the level of developer reward indicates, that for maximizing the cross-side network effect (R1, see Figure 13), the residential plot market side needs more subsidizing. On the contrary, the apartment seeker market side strong enough for decreasing the financial incentives of a platform (increasing the matchmaking fee means smaller savings for apartment seekers).

Maturity phase

After the early growth phase, there are new challenges ahead. The platform is now functioning well, and it is no time to consider incremental innovations (Parker, Van Alstyne et al. 2016, 199). The maturity phase offers a good opportunity to expand the business logic from the transaction platform towards innovation and a hybrid platform (Cusumano, Yoffie et al. 2019). This kind of platform development requires a re-evaluation of platform governance and architecture. The change from transactional to the hybrid platform is not primarily a technical or governance-related but change in mindset. What is the worldview of managing directors: are the other companies in the same industry seen as competitors or partners? Is doing business a solo sport, or is the primary value in networks?

5.2. Theoretical implications

As many researchers (Cosenz 2017, Groesser, Jovy 2016, Täuscher, Chafac 2016) suggest, there is a need for understanding the dynamic nature of new business ventures. In a startup context, fast and right decisions are needed for succeeding in the critical early phase. This research contributes to this stream of literature, offering a case study with the dynamic development of the strategy for a new business venture.

In the field of the startup business, this research has concentrated on a specific type of business named platform business. The platform aspect changes the focus from traditional key performance indicators (see for example Cosenz, Noto 2018) to the dynamics of the network effect and their feedback loops. An essential finding of this research is that everything falls or succeeds with the network effects. All the strategic decisions made by the platform owner are profoundly solving the question of how to reinforce the positive network effects of different market sides and, at the same time, decrease the negative network effects. The same finding is also underlined by Parker et al. (2016).

If managing the levels of demand and offer is critical for business success, what are the tools for that? In this research, especially matchmaking fee and developer reward emerged as central parameters to control the dynamics of the system. Besides, the decision of whether to emphasize ecosystem innovation or not was important. Multiple scenarios with varying market sizes revealed interesting nonlinear dynamics in the system.

The optimal level of the matchmaking fee varied depending on the balance of the two market sides. Matchmaking fee affects straightly to the apartment seekers and matchmaking decision fraction (by influencing to the total savings of the platform). Therefore, if the apartment seeker market side needs support for fully release the potential of the cross-side network effect, subsidizing it with lowering the matchmaking fee may be the right decision. It is crucial to understand the state and balance of the business ecosystem: is the market already saturated, or is there growth potential?

While matchmaking fee controls the demand side primarily, developer reward is used for managing the offering side of the market. While developer reward correlates positively with all the environmental parameters (platform savings and different market sides), it is, interestingly, staying at level zero in more than half of the scenarios. This indicates that subsidizing the offering market side (landowners or residential plots) does not always leverage the positive network effect between market sides: a sufficient level of demand is needed for paying a developer reward. Due to the specific business portfolio of the platform owner (construction), there are at minimum two plots on a platform in the model. Without this premise, developer reward would presumably be paid also with a smaller user amount of the demand side.

In the model simulations, third-party innovation was increasing the financial resources of the platform owner in every scenario. However, the growth effect varied a lot, depending on the scenario. Also, with this decision, the best results were achieved with situations, that third-party innovation could reinforce the positive cross-side network effect between the two market sides. This effect was mainly executed by increasing the apartment seeker market side and thus enabling more matches. However, if the market was already saturated, the only benefit of ecosystem innovation was a better profit per matched apartment. Therefore, when estimating the influences of ecosystem innovation on the platform, it is crucial to understand whether the innovation is leveraging the positive cross-side network effect or not.

5.3. Limitations and future research

The limitations of the research are mainly related to the research focus. In this research, the focus has been on developing and evaluating the platform strategy for housing development. The research concentrates on primary questions about whether the business idea is working or not. Therefore, there are a bunch of follow-up questions that have been excluded from this research. Analyzing the business concept at a high level and showing that it can succeed under certain circumstances does not imply that the business idea actually works. There are many challenges that need to be solved before a successful platform.

5.3.1. Pain points of the platform

The first big question is related to apartment library and the use of it. This includes both the selection of the apartment (platform filter) and combining the selected apartments to an apartment building. The aim is that with the algorithmic tool and modular design, the selected apartments would smoothly form the whole apartment building. This is easier said than done. The challenge can be avoided with manual architectural designing in the first phase, but when the number of projects increases, it is impossible to handle all of them efficiently manually. This type of machine aided design is often called generative design. At the moment, this branch of design is just taking its first baby steps, so there is a lot to be developed here. The question of apartment library and generative design is crucial for housing platform success since it is in the core of value creation.

Another challenge is about payment transactions, which are one of the essential tools for managing multihoming and locking customers to a platform. When an apartment seeker finds a new home for herself and is going to pay for it, it is crucial that the platform owner controls the money flow.

The third big challenge relates to town planning and urban development processes. In Finland, the government typically has a central role in housing development. As previously told, there is not a pile of residential plots ready-to-build, but instead, there are a lot of outdated town plans that are zoned, especially for a certain development project. Depending on the flexibility of the library, it may be impossible to adapt this modular concept for a particular residential plot and its regulative town plan. When expanding to foreign countries, all these aspects need to be localized. Also, a new approach may raise resistance amongst other stakeholders of the process. The easiest and fastest way is to exploit the current town plan and adapt the modular solution to it.

5.3.2. Four future possibilities

What are the future research opportunities? Having considered the platform business in a systemic level, the next step is to start solving more practical challenges. A good way of doing this is by experimentation. Above, some pain points were already mentioned. From another point of view, what could be the doors not opened yet that would help the platform succeed in the future? A couple of topics are raised here. These themes are gathered during the research process from the interview data.

Community empowering

There is enormous power in the community. This effect is emphasized through the digitalization and opportunities it offers. We are not anymore restricted to our village but can find new communities all over the world. There is also significant potential in communities from the viewpoint of the housing platform. Think about the apartment building with a joyful community of families or musicians. But how to actually empower the community? There is undoubtedly a role for the platform owner, but it is ecosystem innovation that has the best tools for releasing the power of communities.

Energy and financial innovations

Housing is one of the most significant investments a single person does in her life. Typically, one either owns or rents an apartment. The financial function has much potential: who gives money for housing, and for what? Is owning the apartment necessary, or is it the stability that people seek?

One aspect here is the question of energy. Housing is developing towards zero energy consumption and even plus energy solutions, and there are more and more energy innovations that can be adapted to housing. What if the apartment building was producing energy as a power plant? This could dramatically affect the financing of the house: instead of expenditure, the apartment building would be a profitable investment.

Expanding the platform towards complete house building process

This research is restricted to the beginning of the housing development process: the matching of location and the inhabitants. However, the apartment building process has multiple further phases and stakeholders. After matching the residential plot and inhabitants, the *actual project* to be developed emerges. This project needs *a professional housing developer* who takes care of the project until the end. As a next step, *architectural designers* and all the *special designers* are needed to finish the design.

Also, when there's a project with a professional in charge of it, there's a need for finishing the design: *architectural designers* and all the *special designer*s. After designing the building, it needs to be constructed. In this phase, stakeholders include contractors and suppliers.

The platform could expand to cover also these further demand – offering pairs. The core topic here again is value creation: what would both sides of the platform benefit from joining to the platform? Re-evaluation of the platform's architecture is needed. Also, monetization should be carefully thought of.

The flexibility of existing apartments

The last topic widens the perspective to totally new markets: the existing apartments. The apartment can be sold as new only once. When, for some reason or the other, it comes for sale again, it is not new and customized by apartments seeker, but it is what it happens to be. There is a vast potential in used apartment markets. How to retain the flexibility and transformability of the apartment during its whole lifecycle? How could an apartment also adapt to the next inhabitant's needs? This is a broad question with significant technical challenges to be solved. However, primarily this kind of change challenges our minds and conventional processes.

6. SUMMARY

In this research, platform business has been developed and evaluated using system dynamics. The main research question was: How to reshape the housing development with platform strategy? The research was commissioned by a Finnish construction company, which has been developing a platform strategy-based business model for housing development. This research was restricted to the beginning of the housing development process: to combining the residential plot and inhabitants.

In order to answer the main question, several sub-questions were presented. The first three sub-questions concentrated on theoretical aspects of the main research question. These themes are multi-sided platforms, system dynamics, and lastly, the systemic development of platform business. The other sub-questions were related to the empirical part. These questions consider the dynamics of the platform: how is the operational environment influencing the platform? What are the strategic decisions needed? What does third-party innovation mean from the platform owner’s perspective? In short, the answer to the main question is: Housing development process reshaped by platform strategy is financially possible within certain minimum values of the operational environment. In order to achieve a successful platform, several aspects of platform architecture, governance, launch, subsidizing, and monetizing need to be considered.

The theoretical part of the thesis was divided into three corresponding parts with theory-related sub-questions. Firstly, the concept of a digital platform was discussed (RQ1). Digital platforms are platforms exploiting digital opportunities for bringing people together. Typically, these platforms are multi-sided by nature (Hagiu, Wright 2015). The role of the platform is to be a mediator between these user groups, in other words, between demand and offer, or consumer and producer. Platforms were also defined by their type based on Gusumano, Gawer and Yoffie (Cusumano, Yoffie et al. 2019). The *transaction platform* captures value for the interaction of the different market sides, whereas the *innovation platform* involves third parties to innovate and thus add value to the platform. These two basic platform types can also be combined into *a hybrid platform*.

The second part of the theory chapter considers systems thinking and system dynamics (RQ2). Systems thinking sees the world as systems, and it emerged as a critique for the reductionist thought that the whole is the sum of its parts. These systems can be found everywhere, and usually, they are complex and dynamic. Instead of the false cause-effect -relations, these systems are based on feedback loops, where the variables of the system interact with each other in a complex and diverse way. System dynamics is based on the systemic worldview, but it stretches towards the computer-aided simulation of complex systems. Apart from other systems thinking forms, system dynamics uses simulation. Simulation is an inseparable part that complements the model-basis analysis. With simulation, it is possible to test the model behavior with different scenarios and thus add the understanding of the problem.

The third theory part concentrated on a systemic view of platforms and startup business development (RQ3). Examples were given in order to get into the topic.

The research was conducted according to system dynamic methodology. The five-step process includes the following steps: (1) problem articulation and boundary selection, (2) formulation of dynamic hypothesis, (3) formulation of a simulation model, (4) testing and, (5) policy design and evaluation. Besides, various group model building technics were used in order to gather data from the company. There was a total of six personal interviews and two group meetings during the research process. Besides, several meetings and discussions with the supervisor from the organization were held.

The system dynamics model was built according to methodology using many typical tools: model boundary chart, sector map, two different causal loop diagrams (network effects and the system itself), and stock and flow map. The model was developed continuously and iteratively with organization and modeler experts. Also, model testing and evaluation were done. Three main parameters of the operational environment were defined: *residential plot market size*, *apartment seeker market size*, and *initial savings of the platform* (answer to RQ4). These parameters were varied in order to get different scenarios of the operational environment. Also, key strategic decisions were recognized. These variables were named as *matchmaking fee*, *developer reward*, *initial library size* and *initial platform quality* (answer to RQ5). The optimal values of these strategic variables were examined in each scenario setting. Also, the importance of the hybrid platform (RQ6) was emphasized based on modeling results. The results of the simulation reveal that the business concept is financially successful with certain environmental limits. Many policy design recommendations were given for different platform maturity phases.

The research was focused on a relatively abstract systemic level. Therefore, there are a lot of practical-level challenges to be solved before the successful platform. Here, three pain points very emphasized: payment transactions, generic design of building apartments and residential plots, and at last, the integration to current housing development processes with town planning processes.

Finally, a couple of future possibilities were briefly presented. These include community-enhancing, energy and financial innovations, expanding the platform towards complete house building process and flexibility of existing apartments.

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APPENDICES

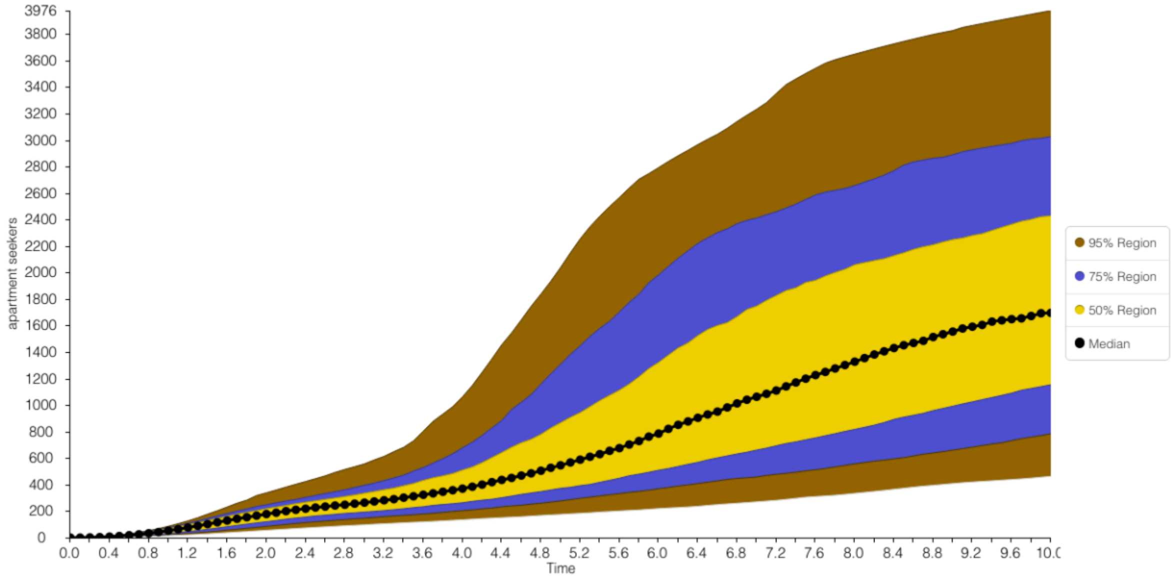
Appendix 1. System dynamic model variables and with equations. The variables are divided according to the sector map.

Name	Equation/parameter value	Unit
QUALITY SECTOR		
matchmaking fee %	(strategic, optimizable parameter)	-
developer reward %	(strategic, optimizable parameter)	-
library size	(strategic, optimizable parameter)	Apartment
platform quality	(strategic, optimizable parameter)	-
initial platform savings %	0.02 / 0.05 / 0.10 (varied with scenarios)	-
total platform savings %	[initial platform savings %]+[3rd party innovation]*0.5	-
platform value	[fraction of potential home seekers by library_total]*[attractiveness of cost savings]*[additional value of community enhancement]	-
platform quality with data effect	[platform quality]+[data resources]*0.2	-
development total costs	[library development costs]+[platform development costs]	€
platform development costs	Pulse(0,-Ln(1-[platform quality]/0.8)*400000,0.9)+0.1*-Ln(1-[platform quality]/0.8)*400000	€
library development costs	Pulse(0,[library size]*1000,0.9)+[library size]*100	€
matchmaking decision by library	1/(1+e^-(0.07*([effective library size]-120)))	Apartment/user
matchmaking decision by price	1/(1+e^-(100*([home savings %]-0.03)))	-
matchmaking decision fraction	[matchmaking decision by library]*[matchmaking decision by price]*[platform quality with data effect]	Apartment/user
fraction of potential home seekers by library_blue ocean	0.25/(1+e^-(0.1*([effective library size]-150)))	-
fraction of potential home seekers by library_red ocean	0.75*(1-e^-([effective library size]/50))	-
fraction of potential home seekers by library_total	[fraction of potential home seekers by library_red ocean]+[fraction of potential home seekers by library_blue ocean]	-
fraction of potential plots by library	1-e^-([effective library size]/50)	-
home savings %	[total platform savings %]-[developer reward %]-[matchmaking fee %]	-
max innovation effectiveness	0.2	-
innovation adjuster	0 or 1 (controls 3rd-party innovation: off / on)	-
library quality	0.8+[data resources]*0.2	-

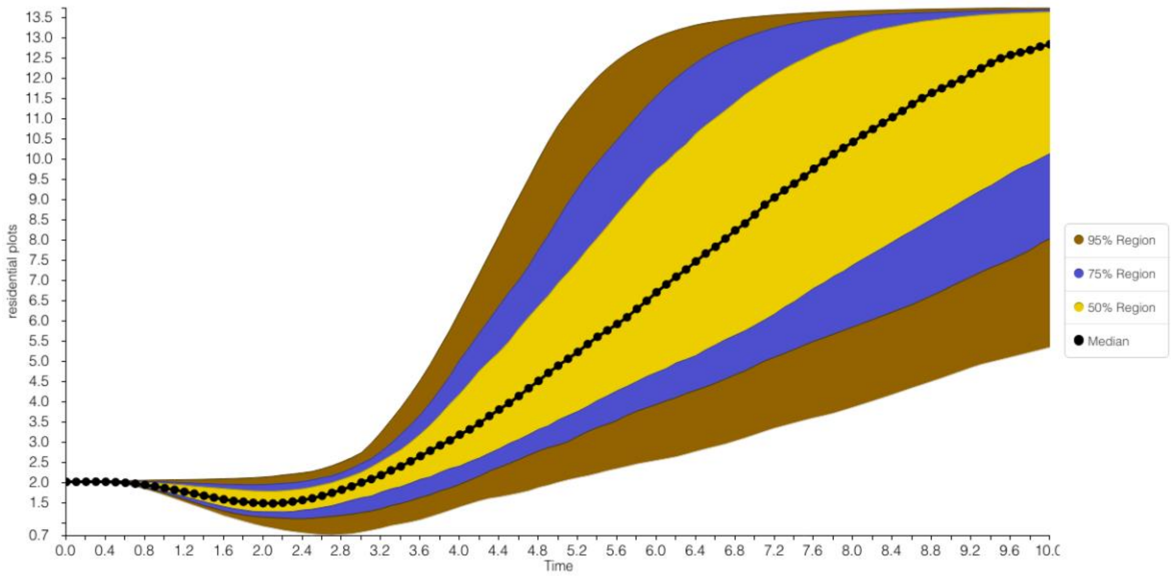
effective library size	0.4*[library size]*[library quality]	Apartment
attractiveness of cost savings	100^[home savings %]	-
attractiveness of developer reward	1-e^-([developer reward %]/0.01)	-
average apartment price	300000	€/apartment
matchmaking fee €	[matchmaking fee %]*[average apartment price]	€/apartment
3rd party innovation	[data resources]*[max innovation effectiveness]*[innovation adjuster]	-
additional value of community enhancement	1+[3rd party innovation]	-
USER SECTOR		
apartment seekers		
potential apartment seekers	∑[change of potential apartment seekers]	User
apartment seekers	∑[adoption rate_AS]	User
change of potential apartment seekers	[potential apartment seekers by platform value]-[potential apartment seekers]-[apartment seekers]	User
adoption rate_AS	[adoption from WoM_AS]+[adoption from marketing_AS]	User/year
apartment seeker market size	10000	User
potential apartment seekers by platform value	[apartment seekers market size]*[platform value]	User
potential apartment seekers by platform value and location	[potential apartment seekers by platform value]*[suitability of locations]	User
suitability of locations	1-e^-([residential plots]/[number of plots needed for 3/5 suitability])	-
number of plots needed for 3/5 suitability	50	Plot
the difference of potential and current seekers	[potential apartment seekers by platform value and location]-[apartment seekers]	User
adoption fraction by platform value and location	-0.05+0.1/(1+e^-(0.002*([the difference of potential and current seekers])))	-
adoption from marketing_AS	[potential apartment seekers]*[advertising effectiveness_AS]	User/year
adoption from WoM_AS	[apartment seekers]*[contact rate_AS]*[adoption fraction by platform value and location]*[potential apartment seekers]/[potential apartment deals by platform value]	User/year
advertising effectiveness_AS	0.02	1/year
contact rate_AS	100	1/year
matched apartments	IfThenElse([apartment seekers]*[matchmaking decision fraction]>[apartments available],[apartments available],[apartment seekers]*[matchmaking decision fraction])	Apartment
residential plots		
potential residential plots	∑[change of potential residential plots]	Plot
residential plots	∑[adoption rate_RP] (initial value: 2)	Plot

change of potential residential plots	[potential residential plots by value]-[potential residential plots]-[residential plots]	Plot
adoption rate_RP	[adoption from WoM_RP]+[adoption from marketing_RP]	Plot/year
residential plot market size	5 / 10 / 20 / 50 (varied with scenarios)	Plot
potential residential plots by value	[min potential plots]+([residential plot market size]-[min potential plots])*[fraction of potential plots by library]*[attractiveness of developer reward]	Plot
adoption from WoM_RP	[residential plots]*[contact rate_RP]*[adoption fraction by demand_delay]*[potential residential plots]/[potential residential plots by value]	User/year
adoption from marketing_RP	[potential residential plots]*[advertising effectiveness_RP]	User/year
advertising effectiveness_RP	0.02	1/year
min potential plots	2	Plot
contact rate_RP	10	Plot/year
apartments available	[residential plots]*[ratio of plot to apartment]	Apartment
ratio of plot to apartment	100	Apartment/plot
ratio of matched apartments to apartments available	[matched apartments]/[apartments available]	-
adoption fraction by demand	[ratio of sold apartments to apartments available]*0.2-0.1	-
adoption fraction by demand_delay	Delay1([adoption fraction by demand],1,0)	-
RESOURCE SECTOR		
cumulative matched apartments	∑[matched apartments]	Apartment
cumulative income	∑[annual income]	€
financial resources	∑([annual income]-[annual costs])	€
matched apartment erosion	[cumulative matched apartments]*0.05	Apartment
annual costs	[development total costs]+[maintenance costs]	€
annual income	[sold apartments]*[matchmaking fee €]	€
maintenance costs	[fixed maintenance costs]+[apartment seekers]*10+[sold apartments]*100+[residential plots]*1000	€
fixed maintenance costs	100000	€
data resources	1-e^-([cumulative matched apartments]/[matched apartments needed for 3/5 data resources])	-
matched apartments needed for 3/5 data resources	5000	Apartment
annual profit	[annual income]-[annual costs]	€

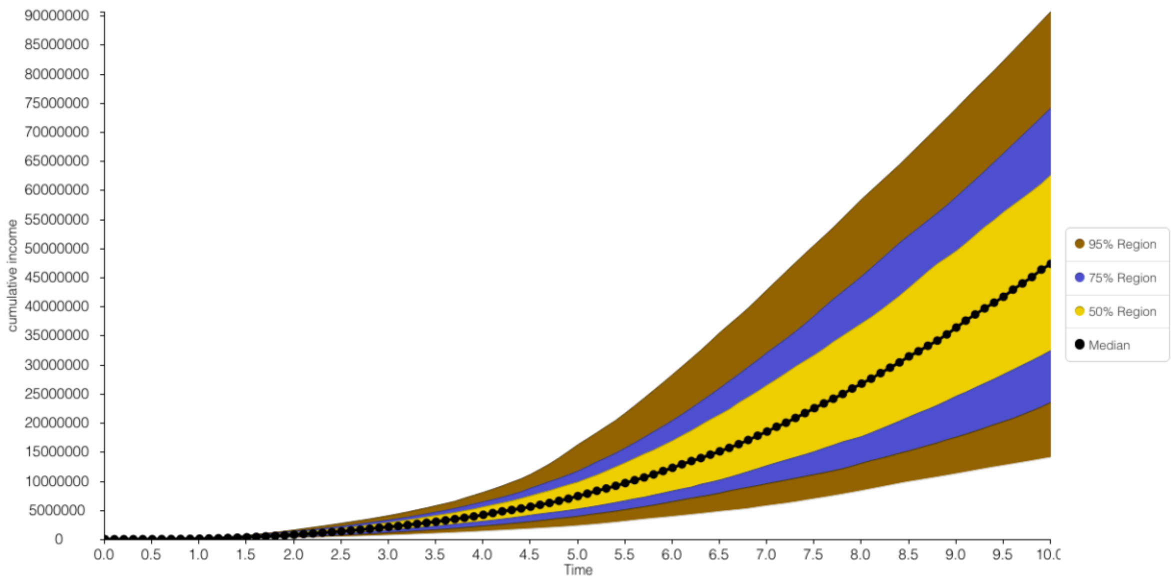
Appendix 2. Sensitivity testing of the model.



Sensitivity testing, apartment seekers on a platform. See chapter 3.5.4 for details.

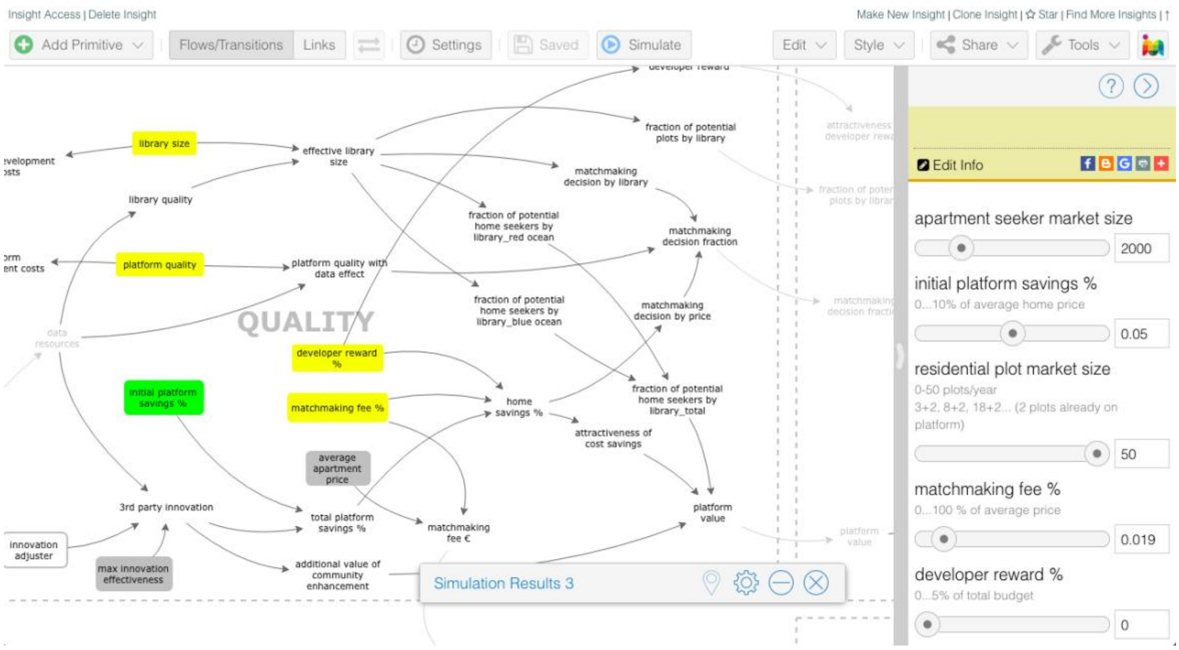


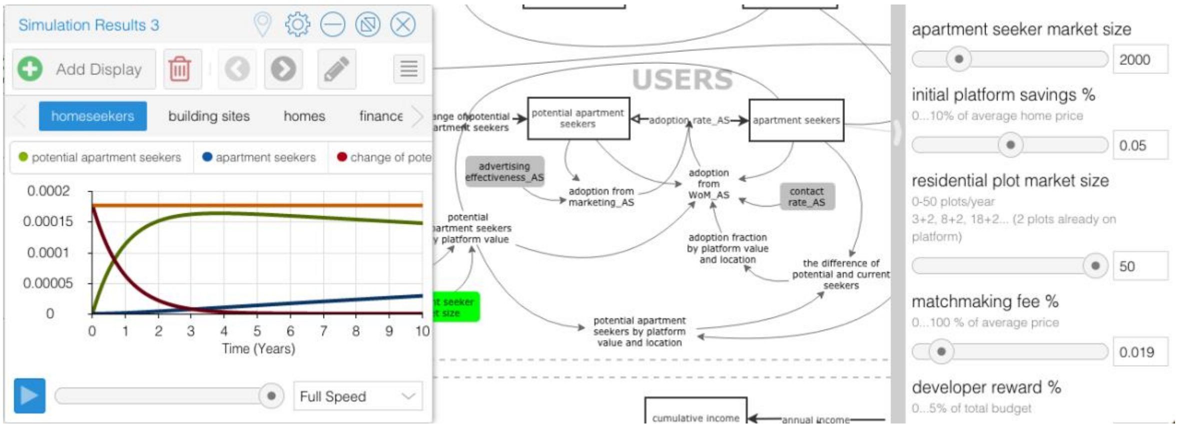
Sensitivity testing, residential plots on a platform. See chapter 3.5.4 for details.



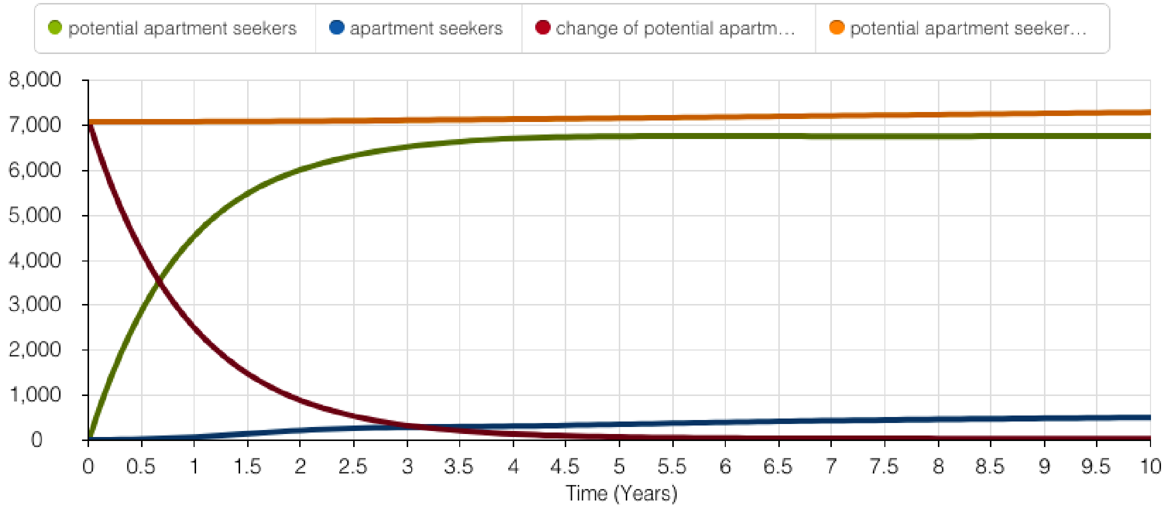
Sensitivity testing, cumulative income of the platform. See chapter 3.5.4 for details.

Appendix 3. Screenshots from the system dynamic model in InsightMaker.





Simulation Results 3
Add Display
homeseekers
building sites
homes
finance
potential apartment seekers
apartment seekers
change of pote
0.0002
0.00015
0.0001
0.00005
0
0 1 2 3 4 5 6 7 8 9 10
Time (Years)
Full Speed
USERS
potential apartment seekers
adoption rate_AS
apartment seekers
advertising effectiveness_AS
adoption from marketing_AS
adoption from WoM_AS
contact rate_AS
adoption fraction by platform value and location
the difference of potential and current seekers
potential apartment seekers by platform value and location
cumulative income
annual income
apartment seeker market size
2000
initial platform savings %
0...10% of average home price
0.05
residential plot market size
0-50 plots/year
3+2, 8+2, 18+2... (2 plots already on platform)
50
matchmaking fee %
0...100 % of average price
0.019
developer reward %
0...5% of total budget



potential apartment seekers
apartment seekers
change of potential apartm...
potential apartment seeker...
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10
Time (Years)