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RESPONSIBLE MANAGEMENT IN FINNISH HOME CARE ENVIRONMENT - MODELING SOCIETAL AND COMPANY LEVEL EFFECTS

Master of Science Thesis

Examiner: prof. Risto Ritala
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ABSTRACT

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Finnish public home care providers will confront major challenges due to the aging of society. The change in the operational environment is predicted to be drastic. As a result, the workload in the home care services will increase, the availability of skillful workforce will decrease, and there are fewer people to support public services. Furthermore, the financial crisis in 2008 caused a sustainability gap in the Finnish government finance, which has led to a political decision to decrease the costs of healthcare. Therefore, the public home care providers will meet a challenge to serve more customers with less resources, which requires innovation of novel methods to maintain the service quality in public elderly care. System dynamics modeling was used to enhance the understanding of the operational environment of public home care providers, and to evaluate responsible management as a potential solution for the challenges. The modeling was guided by the case home care organizations' primary interest in the governance part of responsible management, and their ultimate target to maintain customers' quality of life.

The structural analysis of the model discovered that the dynamics of the system mainly results from the interaction of three balancing and four self-reinforcing feedback loops. According to the structural analysis, the work pressure is an important variable in the system. The analysis proposes that home care providers should have adequate resources to avoid vicious cycles. If the system ended up in a vicious cycle, the elderly care system would produce poor quality and high costs. The simulation analysis evaluated the outcomes of three budget policies and two technology policies. The analysis revealed that the dynamic budget was the only budget policy that allowed adequate resources for the home care provider to manage the increased workload. Both static budget and constant resources policies were not able to prevent the system from drifting to a vicious cycle. The selected technology policy had a smaller impact on the functioning of the elderly care but affected the overall costs.

The policy design suggested that the budget policy should take into account the changes of key indicators in the operational environment. This would allow a budget policy that ensures sufficient resources for the home care provider but prevents overspending due to a careless management. The trends of customers and their health are potential key indicators. The policy design also proposed that technological applications should be included in the home care operations to improve the cost efficiency. Another discovered method to improve the cost efficiency is to recruit sufficient number of employees to avoid the need for costly temporary workforce.

TIIVISTELMÄ

MARKUS MÄKINEN: Vastuullinen johtaminen suomalaisessa kotihoidossa - Vaikutusten mallintaminen yhteiskunnan ja yrityksen tasolla
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Väestön ikääntyminen aiheuttaa merkittävän muutoksen julkisten kotihoito-organisaatioiden toimintaympäristössä. Väestön ikääntymisen seurauksena asiakasmäärä kasvaa kotihoitopalveluissa, osaavan henkilöstön saatavuus markkinoilta heikentyy, ja huoltosuhde kasvaa. Vuoden 2008 finanssikriisi aiheutti lisäksi kestävyysvajeen Suomen valtiontalouteen, jonka seurauksena on tehty päätös vähentää terveydenhuollon kustannuksia. Julkiset kotihoito-organisaatiot kohtaavat täten haasteen palvella suurempaa asiakasjoukkoa pienemmillä resursseilla. Jotta julkisen vanhustenhoidon palvelun laatu säilyisi toimintaympäristön muutoksessa, joutuvat kotihoito-organisaatiot ja julkiset päättäjät kehittämään uusia menetelmiä ja toimintatapoja kotihoidon järjestämiseksi. Työssä hyödynnettiin systeemidynaamista mallinnusta kotihoidon toimintaympäristön ymmärryksen lisäämiseksi ja vastuullisen johtamisen arvioimiseksi ratkaisuvaihtoehtona haasteeseen. Mallinnusta ohjasi kotihoidon tavoite säilyttää asiakkaiden elämänlaatu, ja case kotihoito-organisaatioiden kiinnostus hallinto-osuuteen vastuullisessa johtamisessa.

Mallin rakenteellinen analyysi paljasti, että systeemin dynamiikka on pääasiassa seurausta kolmesta tasapainottavasta takaisinkytkennästä ja neljästä itseään voimistavasta takaisinkytkennästä. Rakenteellinen analyysi myös osoitti, että työn paine on tärkeä parametri systeemin käyttäytymisen kannalta. Lisäksi rakenteellinen analyysi ehdottaa, että kotihoito-organisaatioille tulisi allokoida riittävästi resursseja, jotta vältetään noidankehään joutuminen. Mikäli systeemi ajautuisi noidankehään, julkinen vanhustenhoito tuottaisi huonoa laatua korkeilla kustannuksilla. Simulaatioanalyysissä puolestaan tutkittiin kolmen budjettipolitiikan ja kahden teknologiapolitiikan vaikutuksia systeemissä. Simulaatioanalyysi paljasti, että dynaaminen budjetti oli ainoa budjettipolitiikka, joka mahdollisti kotihoidolle riittävät resurssit kasvavan työmäärän hoitamiseksi. Muut budjettipolitiikat, staattinen budjetti ja vakioidut resurssit, eivät pystyneet estämään systeemiä joutumasta noidankehään. Teknologiapolitiikan valinnalla oli pienemmät seuraukset systeemin toimintaan, mutta vaikutus syntyneisiin vanhustenhuollon kustannuksiin.

Mallin analysointiin perustuva politiikkasuunnittelu ehdotti, että budjettipolitiikan tulisi perustua toimintaympäristöä havainnoivien avainmittareiden muutokseen. Täten budjettipolitiikka mahdollistaisi kotihoidolle riittävät resurssit, mutta estäisi resurssien tuhlauksen. Asiakasmäärän ja asiakkaiden terveydentilan trendit ovat potentiaalisia avainmittareita. Politiikkasuunnittelu suositti myös teknologian hyödyntämistä kotihoidon kustannustehokkuuden parantamiseksi. Riittävän henkilökunnan rekrytointi kalliin vuokratyövoiman käytön välttämiseksi on toinen kustannustehokkuutta parantava löydös.

PREFACE

This Master of Science thesis was done for the Laboratory of Automation and Hydraulics of Tampere University of Technology (TUT) by the commission of VTT Technical Research Centre of Finland LTD (VTT). The thesis presented and visualized the effects of aging society on public home care services, and provided policy recommendations. A system dynamics model was created in collaboration with two case home care organizations to enhance the understanding of the system.

I would like to thank the case home care organizations for the invaluable insights in the operational environment and functioning of public home care services. Thesis supervisors Professor Risto Ritala of TUT, Principal Scientist Peter Ylén of VTT, and Senior Scientist Veikko Ikonen of VTT I thank for their professional guidance throughout the project. I would also like to thank all of my co-workers at VTT for providing an enthusiastic working environment that was a great support during the thesis work.

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Markus Mäkinen

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

AREA	Anticipate, Reflect, Engage and Act
CCB	Customer Citizenship Behavior
CPB	Customer Participation Behavior
CSR	Corporate Social Responsibility
EC	European Commission
EU	European Union
MEO	Material, Equipment and Other
RRI	Responsible Research and Innovation
SHRM	Society for Human Resources Management
STM	Ministry of Social Affairs and Health
THL	National Institute for Health and Welfare
TUT	Tampere University of Technology
VTT	VTT Technical Research Centre of Finland LTD

1. INTRODUCTION

The aging of society is a global megatrend that comes with the challenges of healthcare and economics. Finnish healthcare system is currently based on public healthcare services provided by municipalities. According to the first section of the Local Government Act [1], municipalities shall advance the wellbeing of their residents and the vitality of their areas, and provide financially, socially and environmentally sustainable services. Municipalities are therefore responsible for the health and wellbeing of its citizens. The aging of society leads to an increase in the number of public healthcare customers, because older people need more caring services. Furthermore, the demographic change reduces the proportion of working age people in the population, which makes it more difficult to recruit the required increasing number of skillful caring personnel. In other words, the aging of society increases the dependency ratio, which causes a workload challenge in public healthcare services. An increase in the dependency ratio will also cause an economic challenge as there will be fewer people in the society to support public services. The public healthcare will therefore meet a triple challenge: higher workload, less skillful employees compared to the need, and less granted resources. Furthermore, the financial crisis in 2008 caused a sustainability gap in the Finnish government finance, which has led to a political decision to reduce the costs in healthcare.

The upcoming workload challenge will be especially difficult for public home care providers, because the social and health strategy of Finland is emphasizing the role of home care as the primary elderly care service [2, p. 11-12]. Due to the urgent need for added knowledge, this thesis focuses on the dynamic effects of the aging society on the home care operations. The aim of the thesis is to enhance the understanding of the changes in the operational environment of public home care providers, and to evaluate the potential of responsible management as a solution for the challenges. Understanding of phenomena in complex systems can be improved by system modeling. System dynamics is the selected methodology because it is an effective method to model and visualize complex systems, and thus enables identification of cause and effect relationships, communication and construction of mental models, and finding systemic leverages. Furthermore, system dynamics excels in enhancing the understanding of the system behavior by identifying and foreseeing both intended and unintended consequences of actions.

Responsible management considers the financial, social, and environmental sustainability of the organization’s operations and functioning. There is not a straightforward process to implement responsible management in an organization but multiple theories have been proposed to describe the principles of responsible management. This thesis utilizes the framework of Responsible Research and Innovation (RRI) [3] as the basis for the responsible management. The framework is, however, slightly modified to better support the decision making in the context of Finnish elderly care.

The system model was created in cooperation with two Finnish public home care providers. The case home care providers provided data and information as well as participated in discussions and the model development. Data, information and insights from the case home care organizations formed the foundations for the model. Scientific studies, political strategies, and other sources of information augmented the knowledge of the system. Moreover, an automatic medicine dispenser robot was modeled as a part of the responsible management. The function of the robot is based on its ability to give the right medicine at the right time for the end-user. Furthermore, the robot reminds and instructs the end-user to take the medicine, and is connected via internet to a remote control software supervised by the home care personnel.

The system dynamics modeling process follows the Sterman's [4, p. 86] proposition of five steps: problem articulation, formulation of dynamic hypothesis, formulation of simulation model, testing, and policy design and evaluation. Nevertheless, the modeling process is presented in three phases: the model, testing and validation, and results. The model section describes the structure and the functioning of the model; the testing and validation section evaluates the model's fit with the real-world system; and the results section present the findings of the thesis. The contributions of this thesis are threefold. Firstly, the structure of the model describes the system elements that generate the dynamic behavior of the system. Secondly, the functioning of the system under different budget and technology policies has been evaluated with numerical simulations. Thirdly, the findings of the structural and simulation analyses are combined to support designing policies. The policy design presents an interpretation of the modeling results and provides policy recommendations according to the findings.

The thesis is organized as follows. I first describe the theoretical background of responsible management, and introduce the theory of system dynamics. Then I describe the model structure and the functioning of a Finnish public home care organization. Next I present the testing and validation of the model. I close with model analyses and policy design, which are concluded in the conclusions. The conclusions also give guidelines for future research.

2. RESPONSIBLE MANAGEMENT

A need for responsibility in business has emerged due to development of technology and society. As the capabilities and utilization possibilities of technology have improved, various fields of responsible management have become crucial operations in order to achieve business success. At the same time people have become more aware of actual and preferred operations of companies, which has driven the customer demand for responsible management as well as creation of new legal requirements. However, complying with the law is just the minimum level of responsibility demanded by governments. Achieving business success due to responsibility requires going beyond the legislation. This section gives theoretical background for responsible management.

Responsible management can be defined in multiple ways. This thesis utilizes the definition of responsible research and innovation (RRI) as the approach for responsibility in business. The first subsection introduces the RRI framework and the second subsection describes responsible management in practice in the context of Finnish home care environment, the focus of this thesis.

2.1 Responsible research and innovation

Responsible research and innovation (RRI) is an approach to anticipate and evaluate potential implications and societal expectations regarding research and innovation [5]. Therefore, RRI is similar concept than corporate social responsibility (CSR). However, RRI is broader in scope because it requires a connection to citizen needs and social desirability [6, p. 26]. RRI aims at:

- improving knowledge on the consequences of the actions,
- assessing outcomes of open options in terms of ethical values and
- discovering requirements for design and development [7, p. 12].

In 2001, European Commission (EC) launched an action plan called Science and Society to set out a strategy to foster public engagement and a sustained dialogue between science and civil societies. Since 2010, the focus of the action plan has been on creation of a concept that responds to the aspirations and ambitions of European citizens: a framework for RRI. [3] The framework is explained in EC documents, refs [3][8], and the following summarizes the essentials of those documents.

The framework consists of six pillars: engagement, gender equality, science education, open access, ethics and governance. The first dimension is **Engagement** of all relevant stakeholders. Engagement implies a participatory dialogue and a multi-actor exchange to foster mutual understanding. It is about to engage researchers, policy makers, industry and civil society in co-creation of research and innovation outcomes. Engagement enables enhanced creativity in research and innovation (R&I) design, societally relevant and desirable R&I outcomes, shorter time to market, greater consumer acceptability and empowered citizens.

Gender equality is the second dimension. There are still much more men working in R&I than women. European Union (EU) has established a regulatory framework on gender equality, which is addressed in European R&I policy through funding. The objectives of gender equality are gender balance in decision-making and research teams, and integrate the gender dimension in R&I content. Achieving gender equality means unlocking the full potential.

The third dimension, **Science education**, is about teaching and educating young people to best use their capacities and to become creators of innovations. The aim is to increase the number of researchers in EU. Achieving a greater number of capable researchers requires enhanced education processes and increased interest of young people in science and technology.

Open access is the fourth dimension. Transparency and accessibility of research and innovation is important for further development of new ideas. The results and data of publicly funded research should be freely available online. Open access would increase the use of scientific results by all actors.

The fifth dimension, **Ethics**, should be an integral part of research. Ethics is not only for advancing ethical aspects, but also for improving research quality. Ethical compliance is pivotal for research excellence. In addition, ethical evaluation increases social relevance and acceptability of R&I outcomes.

Governance, the sixth dimension, is an umbrella term for activities that evaluate or manage the responsibility in R&I. In general, policies, rules, processes and behavior are activities under the term of governance. According to EC, good governance includes five principles: openness, participation, accountability, effectiveness and coherence [9, p. 8].

2.2 Responsible management in practice

The RRI framework is applicable to every function in business, even though RRI was initially created to support research and development process. The six pillars form the foundation of responsible management. However, some pillars are more important in decision making than others in the context of interest in this thesis, the Finnish home care environment.

Genders are quite equal in Finnish healthcare and in Finnish society altogether. Therefore, it is assumed that in this case gender equality needs not be considered without losing any important phenomena or dynamics. If genders were not equal, the society could improve the performance by widening the talent pool to cover the whole population. Improving gender equality and equality in general could also have a positive influence in wellbeing and engagement of several stakeholders.

Interviews with the industrial case company revealed that their business model does not include open access. In their current market situation, it is not favorable to share any knowledge with competitors. Even though many technological innovations emerge in healthcare industry, few large actors control the market. Thus, open innovation could be a huge risk for a SME. Revealing the knowledge behind emerging innovations give large corporations an opportunity to take advantage of SMEs by utilizing the knowledge alongside with their existing infrastructure, relationships and brand. For these reasons, open access is not relevant in this context and is not considered in the model.

Ethics is subconscious but important determinant in decision-making. Ethics is an important pillar in responsible management because businesses either prosper or perish due to decisions. Moreover, customers and ecosystems have recently started to favor ethical solutions and partners globally. Nowadays, technological development and competition have achieved levels that allow customers more freedom to select the most suitable offering. Thus, ethical issues may play a significant role in purchase decisions, if there are multiple options available.

Technology development has increased the impact of human capital on competitiveness and economic growth, which indicates a high importance of two pillars: science education and engagement. This is even more important in employee intensive industries, such as healthcare. Science education is a means to control business performance by managing employee skills and knowledge, and engaging relevant stakeholders is a key determinant of business success. Due to the focus on the responsible management, the most relevant stakeholders are employees and customers. Governance is a collection of activities for evaluating and managing responsibility, which means that governance is a part of every responsible management activity.

Following chapters give more insight in ethics, science education and engagement. Employees and customers are stakeholders that have most impact in business responsibility. Therefore, the theoretical research has focused on internal operations concerning employees, and external operations concerning customers. Engagement theory is presented in two chapters, employee engagement and customer engagement, which clarifies the object of engaging.

2.2.1 Ethics

Ethics is a philosophy that focuses on how to live well, be a good person, do the right things, get along with other people and want the right things in life [10]. Ethics does not give a simple answer of what is right or wrong, because, every decision is a result of a complex process that compares and evaluates possible outcomes to personal values. Ethics is indeed always an individual attribute [11]. For this reason, ethics is normally perceived as a set of moral codes that determine how one acts in different situations [12]. In this document, the focus is on business ethics. However, organizations consists of people and people have individual ethics and moral codes.

Business ethics has many dimensions. It is not only about fair competition or responsibility. Business ethics also involves aspects similar to general ethics, including a strong code of ethics, norms and behavior. On the one hand, a company must seek the profit to survive in the short term challenges and to avoid bankruptcy. On the other hand, ethical responsibility of the business is crucial for attaining customer trust and thriving in the long term. [13] Thus, one can see business ethics as a combination of profit maximization and social responsibility. However, differing conclusions have also been presented.

Milton Friedman [14] argued in his article, published in 1970s, that increasing profit is the social responsibility of business. Friedman rationalizes the argument by explaining that many "socially responsible" actions initially comes from selfish interests of the company. For example, increasing appreciation of ethical values among customers can force companies to promote similar values in order to survive in a competitive environment. Furthermore, unethical values and actions may increase the risk of harmful word of mouth and sabotages.

Friedman's argument is supported by neoclassical economic theory that states that in competitive markets, such as modern Western economies, profit maximization allocates resources efficiently. Profit maximization also generates the largest consumer surplus, which means that the price consumers are willing to pay subtracted by the market price is maximized. In this case, the good of the company is also the good for consumers. However, neoclassical theory assumes perfect competition, which differs from reality in many situations, and does not take into account any other human values than the satisfaction of efficient usage of resources. The shortcomings of economic models have resulted in competition regulations and corresponding laws. [15]

Could a company be more profitable by acting responsible from ethical point of view? Many studies support the theory that ethics increases the profit, but others do not find any positive relationship between CSR and profit. Even though there is not consensus about the relationship between ethics and profit, research has discovered that environmental pollution, corporate philanthropy and information disclosure have the greatest effect on market share. [12] Thus, business ethics can augment economical models to reflect better with reality, and increase profits of a company.

The confirmed effects of business ethics on profit suggest that business ethics probably has the most direct effects on branding, marketing and recruiting. According to a survey of a large South-African multinational corporation containing 129 supplier representatives and 28 members of staff, ethical business practices create good reputation in the minds of customers [16]. Business ethics also determines brand personality, which is a major driver for strengthening consumer's attitudes and purchasing intentions [17][18]. In addition to external customers, the theory of business ethics can be augmented to internal operations. Employees are internal customers that trade their time for salary. Thus, business ethics determines also internal brand personality that will spread among the professionals. Famous brand personality should attract, therefore make it easier to recruit, employees that share similar ethical standards with the organization.

Previous paragraphs present evidence about positive effects of business ethics on business success. One can argue that both business ideologies, profit maximization and ethical business, will actually lead to the same result in the present Western economy. Nevertheless, ethics could be a major competitive advantage and should be considered in an organization. However, are there any means to improve ethical thinking in organization? Speaking up and collaborating with diverse personal network have been suggested to improve ethics inside a company [19]. Another, yet quite similar, method is to raise ethical thinking by education, which leads us to the next chapter—Science education [13].

2.2.2 Science education

Human capital is in a crucial role in the modern knowledge-intensive economy that demands highly skilled people [20]. Therefore, science education in this document refers to education of employees, which enables maintaining or obtaining necessary job related skills. Education and training enhances the skills and capabilities of the workforce, resulting in better performance and productivity. In addition, without education and training, the quality of the workforce will erode due to obsolescence and depreciation of current skills [21][22]. Table 1 concludes causes of skill erosion in the workforce.

From economic point of view, there appears to be two types of skill obsolescence: technical skill obsolescence and economic skill obsolescence. Technical skill obsolescence originates from changes in workers, which affect their human capital. Economic skill obsolescence, instead, is a result of changes in the work environment. Therefore, technical skill obsolescence describes depreciation of the human capital, whereas economic skill obsolescence affects the market value of the human capital. [23]

The wear and atrophy of skills are types of technical skill obsolescence. The wear of skills results from the natural aging process, injuries or illnesses. In other words, working, aging and unfortunate incidents wear the employee, which has a negative influence on the employee's human capital. The insufficient use of skills, on the other hand, make these skills to atrophy. Unemployment and working below the obtained level of education are common reasons to insufficient skill usage. [23]

Three types of economic skill obsolescence can be distinguished: job-specific skill obsolescence, skill obsolescence by sectoral shift and firms-specific skill obsolescence. Technological, methodological and organizational developments in business processes re-define work practices, which may change the skill demand for employees. Skill obsolescence by sectoral shift means that the employees' human capital do not change and they are still equally capable for exercising their occupation, but the demand for the profession declines. Firm-specific skill obsolescence, instead, occurs if there is external or internal turnover in the workforce. Part of the knowledge gathered by experienced employees are only applicable in a certain firm or department. Thus, employee turnover causes firm or department specific skills to lose their value. [23]

In addition to individual related skill obsolescence, organization may occur skill depreciation due to organizational forgetting. The aggregate of wear of individual skills or employees with firm-specific skills quitting are causes of organizational forgetting. [23] Thus, organizational forgetting is related to obsolescence of firm-specific skills. If there is a high turnover of experienced employees, the organization suffers from a high depreciation of firm-specific skills. Depreciation of firm-specific skills results to organizational forgetting if the turnover of experienced employees is severe enough to prevent the transfer of knowledge from experienced employees to novice ones.

***Table 1: Types of skill obsolescence. Adapted from the study of De Grip and Van Loo* [23, p. 4].**

Type of skill obsolescence:	**Human capital depreciation by:**
Technical skill obsolescence	
Wear	Natural ageing process, illnesses and injuries
Atrophy	Insufficient use of skills
Economic skill obsolescence	
Job-specific skill obsolescence	New skill requirements due to various developments in society
Skill obsolescence by sectoral shift	Declining employment in occupation or economic sector
Firm-specific skill obsolescence	Employee mobility
Organizational forgetting	
	The aggregate of wear of skills of individual employees, or mobility of workers with firm-specific skills

The increasing demand of highly skilled employees has made the investment in human capital a key priority [20]. Continuous on-the-job training is an important activity to tackle the skill obsolescence and to improve the overall quality of the workforce. However, the results of the training depend on the willingness and capabilities of the participating employee [24]. Empirical study based on the Netherlands labor-supply data confirms that willingness to participate in training is statistically significantly explaining variations of job-specific skill obsolescence and skill obsolescence by sectoral shift [24]. Thus, training is a potential remedy for economic skill obsolescence.

Technical skill obsolescence, on the other hand, can be reduced by improving working conditions and redesigning work practices to better support individual employees [24]. The final type of skill obsolescence, organizational forgetting, is closely related to wear of skills and firm-specific knowledge. Thus, by applying activities to treat technical and economic skill obsolescence, organizational forgetting is also reduced. Furthermore, engaging workforce reduces turnover, which is another remedy for organizational forgetting.

Treating the skill depreciation, however, may not be enough in global competition and in ever more complex challenges companies and society face. In order to increase the service level, the value of human capital must be improved. Higher value of human capital can be achieved, if investments in human capital exceed the requirements from skill obsolescence. Another method to increase service level is to support current human capital, for example, by new technology. Nevertheless, seamless co-operation of technology and employees still require employees to obtain new skills.

2.2.3 Employee engagement

Engagement of relevant stakeholders is the first pillar of the RRI. Because employees are internal stakeholders that have a major impact in business responsibility, employee engagement is a part of responsible management in practice. Employee engagement is a widely studied field of business management due to its high potential to improve business performance. The theory of employee engagement is based on concepts like job satisfaction, employee commitment and organizational citizenship behavior [25].

Employee engagement is a fusion of wellbeing, information, fairness and involvement [26]. Engaged employees are willing to go beyond the regular job description to perform excellent results [27]. According to Cook [26], the level of engagement can be summed up in two aspect: how positively employees think and feel about the organization, and how proactively they are acting to achieve organizational goals. The most important influences of employee engagement on business performance are presented in Figure 1.

The effect of employee engagement on productivity and performance is found in multiple research studies, e.g. [25][26][27][28]. By the definition, engaged workers are motivated, which is a major determinant of productivity and performance. Leiter and Bakker [29] describe engaged employees to have the energy and the focus to bring their full potential to the job, and the capacity and the motivation to concentrate exclusively on their current task. The motivation on work may increase the productivity and performance due to higher moral on working and willingness to develop the working process. Research studies have found that employee engagement indeed lowers absenteeism [26], which supports the reasoning before. The negative association between absenteeism and productivity is obvious.

Another important determinant of productivity and performance is the quality of the workforce. Engaged employees are not as likely to consider changing the employer as the unengaged ones: engaging employees lowers the employee turnover [25][26]. Hiring new employees to replace the workforce that have left the company will reduce the quality of the workforce, because resigned employees have obtained experience, for example, in the forms of job and firm-specific information. Even though hired employees would have similar skills and background with the resigned ones, they lack at least the firm-specific knowledge. Engaged workforce is also a great source of internal brand value. Brand value from engaged employees will spread among professionals, similarly with business ethics, which enhances the recruiting. Research studies support the reasoning that employee engagement has a positive influence on recruitment quality [26]. However, if the turnover of employees is extremely low, the innovativeness of the company may reduce due to the lack of fresh ideas. For this reason, a certain level of employee turnover is the desired situation.

As mentioned earlier, engaged employees are pursuing excellence. In many fields of industry, for example, in the industries of the case organizations, manufacturing and healthcare, achieving excellence requires customer centric mindset. There is evidence that engaged employees are more customer centric, which leads to better customer satisfaction [26][30]. Contacting with beneficiaries also allows employees to see the impact of their work, which have been found to maintain motivation [31]. The next subsection gives comprehensive insight in the role of customers.

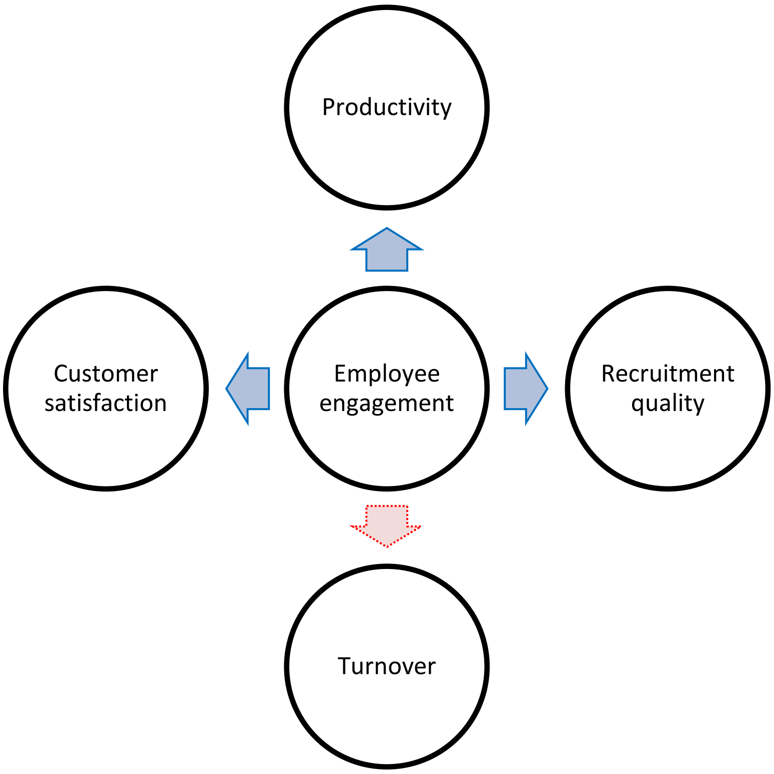

***Figure 1: Employee engagement has a positive influence on productivity, recruitment quality and customer engagement; and a negative influence on turnover. Solid arrows with blue filling represent a positive influence, and dashed arrow with red filling represents a negative influence. Source: Gauttier et al.* [32].**

Benefits of employee engagement are undeniable, but how the engagement can be raised to the next level? Anitha [27] found in her research that working environment and co-worker relationship are the most influential factors on employee engagement. Anitha used data of 383 valid questionnaire answers from small-scale organizations. The research by the Society for Human Resources Management's (SHRM) [33] suggests that the most important determinants of employee engagement are the co-worker relationship, opportunities to use skills and abilities at work, relationship with immediate supervisor, and the work itself, which is in line with Anitha's study.

Based on literature research, Gruman and Saks [28] suggest that engagement facilitation, performance and engagement appraisal as well as feedback are the major drivers for employee engagement. They define the engagement facilitation as a combination of job design, leadership, coaching, supervisor support and training, which in fact has a similar meaning as working environment and co-worker relationship. Performance and engagement appraisal and feedback, on the other hand, refers to justice and trust. Zak's [34] findings support the claim that trust has a positive association with engagement. According to him research based on United States national sample, people at high trust companies report 76 % more engagement than people in low trust companies. His studies also suggest other favorable effects of trust on business, for example, 50 % more productivity and 50 % higher intention to stay with their employer, but these effects are very similar with the effects of improved engagement. Thus, let us keep the focus on the concept of employee engagement.

However, trust is as abstract concept as engagement, which is not serving the topic of responsible management in practice. Thus, we need to find the determinants of trust. Zak [34] proposes seven management behaviors that enhance trust: recognize excellence, set proper goals, enable job crafting, share information, intentionally build relationships, facilitate personal growth, and show vulnerability, which are very similar with the drivers of engagement that Gruman and Saks [28] suggest.

2.2.4 Customer engagement

Customers are the most important external stakeholders of a company. In addition to paying and using the offerings of companies, customers also play a critical role in development of many internal and external operations. Customers of the industry case company in this thesis are home care organizations, whose customers are primarily senior citizens.

Service-dominant logic views customers as co-creators of value and relationships [35], which indicates that the understanding of customers behavior can be augmented beyond customers' buying decision process. According to service marketing literature, there is at least two customer behavior types in service delivery process: customer participation behavior (CPB) and customer citizenship behavior (CCB) [36]. CPB is the expected and required behavior that enables a successful delivery of the service, and CCB is a voluntary behavior that is not required in successful delivery of the service but will help the service providing organization [37]. Unmanned gas stations require customers to use the provided equipment to pay and fill their cars by themselves, which is an example of CPB. Gestures of appreciation, for example, thank you notes and gifts, positive word of mouth, and service improvement suggestions are examples of CCB [38].

Yi's et al. [36] research shows that CPB and CCB have a direct and positive effect on front service employee performance and commitment, and CPB has also a direct and positive effect on front service employee satisfaction. Moreover, these employee variables decrease employee turnover intention. The study cannot confirm the positive effect of CCB on employee satisfaction to be statistically significant. However, they argue that the focus on beneficial customer behavior may be the reason for the lack of significant relationship between CCB and employee satisfaction. [36] Negative customer behavior can appear, for example, in forms of negative word of mouth, fraud, uncooperativeness and rude customer behavior [39]. The negative forms of customer behavior can cause dissatisfaction to front service employees [36].

Pansari and Kumar [40] define customer engagement as "the mechanics of a customer's value addition to the firm, either through direct or/and indirect contribution". Direct contributions refer to customer purchases, and indirect contributions refer to customer referrals, social media conversations about the brand as well as customer feedback and suggestions to the firm. The definition of the customer engagement suggests that improved customer engagement leads to favorable CPB and CCB. Due to positive customer behavior, customer engagement has a positive influence on front service employee engagement.

Pansari and Kumar [40] further argue that customer satisfaction and emotions are antecedents for customer engagement because customer satisfaction has a positive relationship with direct customer contribution, and positive emotions towards the brand will lead to higher indirect customer contribution. The argument has support from other researchers. For example, Henning-Thurau's and Gremler's [41] research shows that customer satisfaction has a direct and positive effect on customer commitment, loyalty and word of mouth; and Yi et al. [30] confirm that customer satisfaction increases customer commitment and CCB as well as decreases customer dysfunctional behavior. Furthermore, Bijmolt et al. [42] have distinguished three general manifestations of indirect customer engagement: word of mouth, customer co-creation and complaining behavior.

This section has shown that customer engagement is an indicator for customer behavior. High level of customer engagement helps many internal and external company operations. Sales and service quality are improved by better commitment, loyalty and positive customer behavior towards front service employees; marketing is improved by positive word of mouth; and business development as well as R&D are improved due to co-creation, feedback and improvement suggestions.

3. SYSTEM DYNAMICS

System dynamics is a process and a tool to improve understanding of large and complex entities, systems. System dynamics produces a model and an analysis that help decision makers to understand the behavior of the system, and therefore, enable better decisions. Every decision is based on some model, although rather often the decision maker is not conscious about her implicit mental model [4, p. 16-17]. By applying the system dynamics approach, decision makers are able to explicate the system model and choose the most appropriate and useful model for the particular decision making situation. Evaluation of the explicit model enables decision makers to be confident that their decisions are based on reliable models. However, every model is a simplification of reality, which means that it is not possible nor reasonable to attempt to build a perfect model. If the model was a perfect replication of reality, it would also be as complex to interpret. Therefore, a quote from George Box is a good reminder for every modeler and decision maker.

> *"All models are wrong, but some models are useful."*
> *George E.P. Box, 1979, Robustness in the strategy of scientific model building in Robustness in Statistics, R.L. Launer and G.N. Wilkinson, Editors. 1979, Academic Press: New York.*

The definition of system dynamics is presented in the first subsection. The second subsection introduces the system dynamics modeling process. The third subsection discusses the benefits of system dynamics.

3.1 Definition of system dynamics[1]

Arnold and Wade [43] provide a comprehensive definition of system dynamics. Their definition has compiled many previous definitions in a compact and easily understandable form that contains eight elements. The following reviews their definition as presented in [43].

1. **Recognize interconnections**

   Recognizing interconnections is the base of system dynamics, which aims to identify relationships and connections between elements of a system. Unfortunately, identifying relevant interconnections is not an easy task. Even highly educated people tend to lack intuition on interconnections, which leads to a narrow focus and failing to recognize comprehensively internal interconnections of the system [44].

[1] This subsection has been published as a separate article in Mäkinen, Systeemidynaaminen ennakointi, Futura, 3/2017, pp. 5-17, with only minor modifications.

2. Identify and understand feedback

Closed causal (cause-effect) chains form systemic feedbacks [45]. Identifying and understanding feedback loops is important in system dynamics because feedbacks create systemic behavior that amplifies or limits changes in the system. Feedback loops that cause amplifying behavior are called self-reinforcing feedback loops. Pushing a snowball from the top of a mountain is an example of self-reinforcing behavior. The snowball will roll downwards at increasing size and velocity. On the other hand, feedbacks that limit changes in the system are called balancing feedback loops. A mechanical spring is an example of a balancing feedback behavior. By compressing or stretching a spring, the spring's structure will create an opposing force that tries to return the spring to its resting position.

3. Understand system structure

System structure consists of elements and their interconnections. Understanding the system structure requires understanding the interconnections and feedbacks in the system. System dynamics modeling often utilizes graphical models that present recognized interconnections and feedback loops. A graphical model helps in understanding the structure and behavior of the system.

4. Differentiate types of stocks, flows and variables

Stocks in system dynamics elements are that accumulate their inputs and are reduced by their outputs. Inputs and outputs to stocks are referred to as flows. System dynamics may also involve variables, e.g. controls of flows. Differentiating types of stocks, flows and variables enables capturing real system behavior more accurately to a model.

A stock can be either physical or emotional. An example of a physical stock is a sink that stores the water poured down to it. A water tap is a flow that changes the level of the stock, and the opening of the valve in the water tap is an example of a variable that affects the value of the flow. Knowledge is an example of an emotional stock. Training can be a flow to knowledge stock, and resources for training is a possible variable in this system.

5. Identify and understand non-linear relationships

Identifying and understanding non-linear relationships refer to stocks and flows that are naturally non-linear. Real world systems are rarely, if ever, linear. Thus, it is important to identify and understand non-linear relationships to be able to create a useful model. By understanding non-linear relationships, the modeler has justification to evaluate the possibility to simplify the model by linearization.

6. **Understand dynamic behavior**

Interconnections between the elements of the system, feedbacks formed by interconnections, and stocks and flows themselves determine the dynamic behavior of the system. Understanding dynamic behavior is difficult without systems literacy training [44]. Differentiating types of stocks, flows and variables, as well as identifying linear and non-linear interconnections, are keys to understand system's dynamic behavior. Therefore, the dynamic behavior is a function of the internal structure of the system rather than a result of external incidents [45].

7. **Reduce complexity by modeling systems conceptually**

Modeling enables examining the system from multiple viewpoints and simplifying the model structure to focus on the most important dynamic behaviors. Simplification is an effective way to study complex systems. According to research, perceptual wholes can reduce the conscious accessibility of their parts [46]. Operating with wholes, therefore, enables interpretation of theoretically more complex systems, because interpreter's mind can work with reduced amount of details. Modeling is a method to create conceptual wholes while preserving the detailed information related to each whole.

8. **Understand systems at different scales**

Understanding different scales of the system requires expanding the view beyond the personal level of examination, as well as deepening the knowledge about small-scale details. Understanding of different scales can be described as an ability to recognize the forest and understanding the meaning of each tree in the forest. By understanding different scales of the system, the decision maker is able to reduce the complexity of the system by focusing on meaningful scales and setting reasonable borders for the model.

The previous definition covers the system dynamics widely. However, system dynamics can be applied at many levels of knowledge to improve decision making by enhanced system understanding (Figure 2). Plate and Monroe [44] present recognition of interconnections, identification of feedbacks and understanding of dynamic behavior as the basic level of systems thinking. According to them, the intermediate level of systems thinking enables differentiating types of stocks, flows and variables, as well as conceptual modeling. They also argue that simulation modeling and policy testing require advanced skills in systems thinking [44].

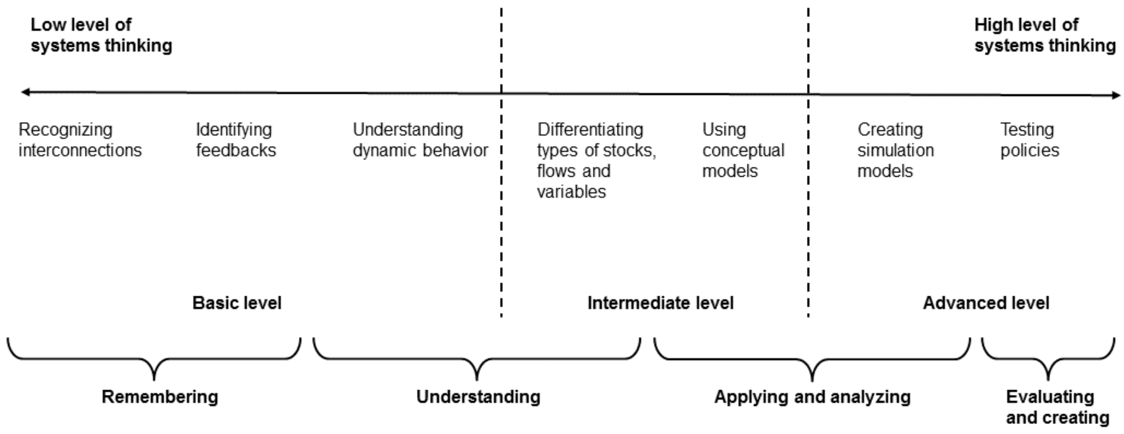

***Figure 2: Levels of systems thinking. Modified from Plate and Monroe* [44].**

Figure 2 shows that system dynamics in decision making is useful even at the very basic level. As the system dynamics skills improve, more possibilities come available to enhance the knowledge of the environment and to improve business operations. The following subsection will describe the process of system dynamics modeling.

3.2 System dynamics modeling process

The definition of system dynamics above described the elements of systemic modeling but did not address how the modeling process should be exercised. Sterman [4, p. 86] proposes that system dynamics modeling process, see Figure 3, should contain five steps: problem articulation, formulation of dynamic hypothesis, formulation of simulation model, testing, and policy design and evaluation. Furthermore, any step of the modeling process may yield insights that require revising previous steps [4, p. 87].

Problem articulation involves identifying the modeling problem, selecting important variables, and setting an appropriate time horizon [4, p. 86][47]. Identifying the modeling problem describes the theme of the modeling process, and selecting important variables determine the key concepts that must be considered. The time horizon should be far enough in the future that relevant long-term consequences will not be neglected and far enough back in the past that the roots of the problem can be detected. [4, p. 86] Gathering historical data can also support initial analysis, present historical behavior of the system, and provide valuable input at problem articulation step [47].

Key variables are system elements that are related to the underlying problem. The identification of key variables can be started by evaluating which variables have the most prominent effect on the objective of the modeling. After the variables representing direct causes to the objective are identified, the modeler can find more important system elements by evaluating causes that will have an effect on the identified key variables. Finding variables will continue similarly until boundaries of the model are reached. However, model boundaries may change during the modeling process, which may require returning to the problem articulation step. Identifying the key variables helps also to recognize important interconnections in the system because a variable is important if it will affect directly or indirectly to the objective of the modeling.

There are numerous methods to identify the key variables and their interconnections. Regardless of the method, interdisciplinary cooperation is usually required in order to form a holistic understanding. Workshops, discussions, interviews and exercises are examples of methods to involve experts, stakeholders and decision makers to the variable identification work.

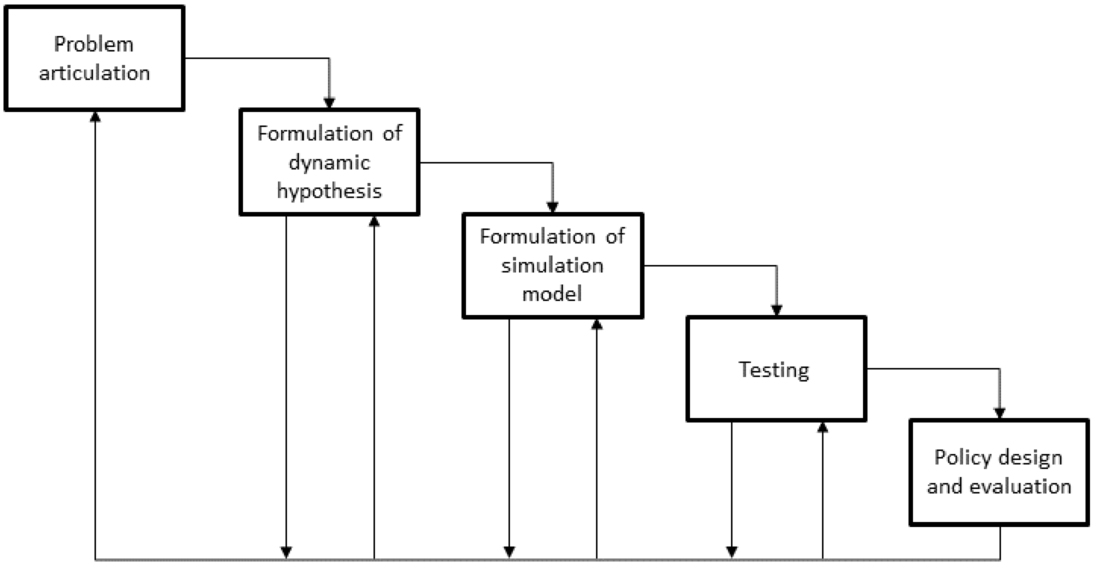

Figure 3: System dynamics modeling process. Modified from Duggan **[47].**

Formulation of dynamic hypothesis aims to explain the problematic system behavior by addressing endogenous consequences [4, p. 86]. In other words, dynamic hypothesis identifies the stock, flow and feedback structure that explains the problematic behavior [47]. Based on initial hypotheses, key variables, historical behavior, and other available data, the problem can be mapped by using different facilitation tools, such as, causal loop diagrams, and stock and flow maps [4, p. 86].

The mapping generates a conceptual model that presents the causal structure of the system. It is useful to differentiate the types of stocks, flows and variables as well as to recognize systemic feedbacks because these system elements determine the dynamic behavior of the system. System elements that do not belong to any feedback loop (exogenous variables) are system's elements that are beyond the model boundaries determined in the problem articulation. Sterman [4, p. 95] argues that exogenous explanations are actually questions of how exogenous variables have ended up in their current states.

Therefore, in case of exogenous variables, the modeler should consider if the model boundary should be augmented to include external variables into feedback loops.

Dynamic hypothesis should be based on endogenous consequences that have scientific soundness. The suggestion for scientific soundness, however, does not mean that existing theories cannot be augmented after new information, but in that occasion, a careful deliberation is recommended. Notwithstanding, a formulation of dynamic hypothesis helps modeling participants and stakeholders to have a fruitful discussion about the underlying problem because every group and individual typically have their own theory for the causes and consequences of the problem [4, p. 95]. The discussion can also reveal incomplete and faulty theories.

After the problem is articulated, dynamic hypothesis is proposed, and a conceptual model is created, they must be tested. In some occasions the correct formulation of the conceptual model can be tested by comparing it to collected data or to tests in the real system. However, in most times the structure of the system is too complex due to unclear dynamic effects for humans to make right interpretations. Furthermore, it can be difficult, dangerous, unethical or impossible to perform test in the real system. In these situation, numerical simulations are the only option for testing. [4, p. 102-103]

Formulation of simulation model means specifying the system structure, adding decision rules, and estimating parameter values, behavioral relationships and initial conditions [4, p. 86]. Simulation requires augmenting interconnections with equations that will explicitly describe the type and the nature of the interconnection. For example, the equation for the volume of a water tank can be defined as the inflow minus the outflow. Formalization of the conceptual model to simulation model helps to recognize and resolve conflicts in the model structure, to reveal unnoticed and undiscussed systemic behavior, and to understand vague concepts [4, p. 103].

Formalization is a good test for the system understanding because computer programs do not allow vague definitions for interconnections. Formulation of a simulation model indeed requires repeated evaluation for consistency with the purpose and the boundaries of the model. In addition, a large variety of tests are developed to identify flaws in formalization and to improve the understanding of the system. [4, p. 103]

Testing is a crucial action in order to achieve reliable modeling results. Testing begins at the same time with the model creation: testing and model formulation are parallel processes, which emphasizes the iterative nature of system dynamics modeling process. If the testing reveals inconsistencies or flaws in the modeling, the modeler should return to previous steps and correct the mistakes. The iterative nature enables continuous improvement of system understanding during the progression of the modeling work.

Formalized model should correspond with the real world system. Evaluation of model boundaries and structure, dimension analysis, parameter assessment, extreme conditions, behavior reproduction, behavioral anomaly, surprise behavior and sensitivity analysis are tests to assess model consistency with the real world [4, p. 860]. Table 2 presents the purpose as well as usable tools and procedures to exercise these tests.

***Table 2: Test for evaluation of the model. Modified from Sterman* [4, p. 859-861].**

Test	**Purpose**	**Tools and procedures**
Boundary and structure assessment	Are important concepts included in the model? Does changing the boundaries affect the behavior of the model or policy recommendations? Is the model structure consistent with current knowledge of the system, physical laws and decision rules?	Mapping tools, such as, causal loop diagrams, and stock and flow maps. Interviews, workshops, literature review, direct participation in processes etc. to capture relevant knowledge. Modify the model to include additional plausible structure; transform constants and exogenous variables to become endogenous ones; and evaluate effects. Partial model test of intended rationality of decision rules. Laboratory experiments to expose mental models and decision rules.
Dimension analysis	Do equations have consistent dimensions without using parameter that do not have a real world meaning?	Usage of dimension analysis software. Inspection of suspected model equations.
Parameter assessment	Are parameter values consistent with current knowledge of the system?	Statistical methods to estimate parameter values. Usage of interviews, expert opinions, literature, experiences, assumptions, etc.
Extreme conditions	Does the model produce reasonable and plausible behavior even with extreme parameter values?	Inspection of every equation. Testing extreme values of every input alone and in combination.
Behavioral reproduction	Is the model able to reproduce the interesting systemic behavior? Does the model generate endogenously the initial problem and various modes of behavior observed in the real system?	Qualitative comparison of model output and data. Statistical methods to measure correspondence.

Behavioral anomaly and surprise behavior	Does changing the assumptions generate anomaly behavior? Does the model reveal unrecognized behavior? Is the model able to anticipate the response of novel system conditions?	Loop knockout test to evaluate the remarkability of feedback loops. Simulation records and future simulations to resolve discrepancies between model behavior and system understanding. Document mental models prior modeling.
Sensitivity analysis	Do the numerical values or modes of behavior change significantly when assumptions about parameter values are varied over a plausible range of uncertainty?	Sensitivity analysis tests. Optimizations to find the parameter combination that generates the best policies, and combinations that generate implausible or reverse policy outcomes.

Even though an important part of testing is comparing the simulated behavior to the actual behavior of the real system, the purpose of the testing is not to replicate collected data [4, p. 103]. The collected data can only describe the behavior of the system at a specific historical time. Therefore, the purpose is instead to verify that variables, equations and simulated behavior correspond to a meaningful real world concepts [4, p. 103].

Policy design and evaluation requires that the model has passed the rigorous testing stage [47]. Once the testing has developed confidence for the structure and the behavior of the model, the model can be used to design and evaluate policy improvements [4, p. 103]. The model itself, however, is rarely adequate for answering the initial modeling problem because decision makers may lack required skills to interpret the model and to come to a correct conclusion. Therefore, model analysis is an important part of modeling in order to achieve initial goals of the process. Structure, scenario and policy analyses are means to generate appropriate modeling results for decision makers. Furthermore, the formulation of a simulation model enables using mathematical optimization in policy design.

Structure analysis focuses on inspecting the feedback structure of the system. The dominance of the feedback loops determine the natural behavior of the system. If a self-reinforcing loop is dominating, the state of the system is diverging after disturbances. Instead, if a balancing loop is dominating, the state of the system will return to an equilibrium after disturbances. The dominance in the system can, however, change as a result of non-linear interconnections, if the state of the system changes enough. For example, no real system can grow infinitely. After the state of the system has changed enough, there will become a critical resource that will prevent the greater growth and change the dominance of feedbacks in the system. Because the dominance of the feedbacks can change, structure analysis aims to find means to utilize system structure to achieve the desired state.

Scenario analysis aims to assess and study the effects of various scenarios. Different scenarios can be created by changing the parameter values and uncertainties, or by adding foreseen phenomena in the model. Scenario analysis has a close relation with sensitivity analysis. Scenario analysis enables finding the best, the worst and other possible outcomes of a particular scenario. Moreover, varying the parameter values and controlling uncertainties gives means to evaluate probabilities for the existence of different scenarios.

Policy analysis focuses on analyzing the results of different policy options. Structure and scenario analysis generate policy recommendations to solve the initial problem. Policy analysis inspects the short- and long-term effects of these policies. The goal is to find if unintended side effects exists, and to fine-tune recommended policies. Policy analysis enables policy recommendations that drive the system holistically towards the desired state and help to give more credible explanation why the recommended policies should be exercised. If policy recommendations have credibility in the eyes of decision makers, the recommendations will more probably find their way into organization’s strategy.

3.3 Benefits of system dynamics[2]

Successful decision making is increasingly difficult in ever complex world, and the functioning of human brains still amplifies the problem. Brains tend to solve problems quickly by jumping to a solution based on past experience [48, p. 11]. This “fast” thinking can, however, be controlled by developing a logical argument that links the data to a diagnosis and, eventually, to the final solution [48, p. 11]. Systems thinking methodologies, such as system dynamics, are examples of more deliberate approaches to solve problems by enhancing the understanding of large and complex entities. System dynamics process as introduced in Section 3.2 sheds light on the dynamic behavior and the structure of the system. Identifying the most important variables and interconnections in the business and operational environment enables decision makers to focus on functions and systemic behaviors that will affect most on the consequences of decisions. A collection of benefits that system dynamics aims to achieve is displayed in Figure 4.

Holistic understanding of a system usually requires interdisciplinary cooperation that combines multiple mental models into a shared understanding. A mental model refer to an individual perception of the system. According to Maani and Cavana [49, p. 15], “mental models reflect the beliefs, values, and assumptions that we personally hold, and they underlie our reasons for doing things the way we do”. System dynamics enables the communication, evaluation and controlled utilization of mental models. Communicating mental models to the whole network is much easier if every mental model can be constructed as an explicit model. The explicit model also enables consistent interpretation and evalu-

[2] This subsection has been published as a separate article in Mäkinen, Systeemidynaaminen ennakointi, Futura, 3/2017, pp. 5-17, with only minor modifications.

ation of the outcomes because the model reveals the assumptions and modelers' interpretation of real world phenomena. Basing decisions only on mental models, especially in complex context that requires interdisciplinary cooperation, may lead to unintended results, if decision makers and advising experts do not share the interpretation of the system. Furthermore, system dynamics is an effective tool to improve the mental models of decision makers, experts and other modeling participants.

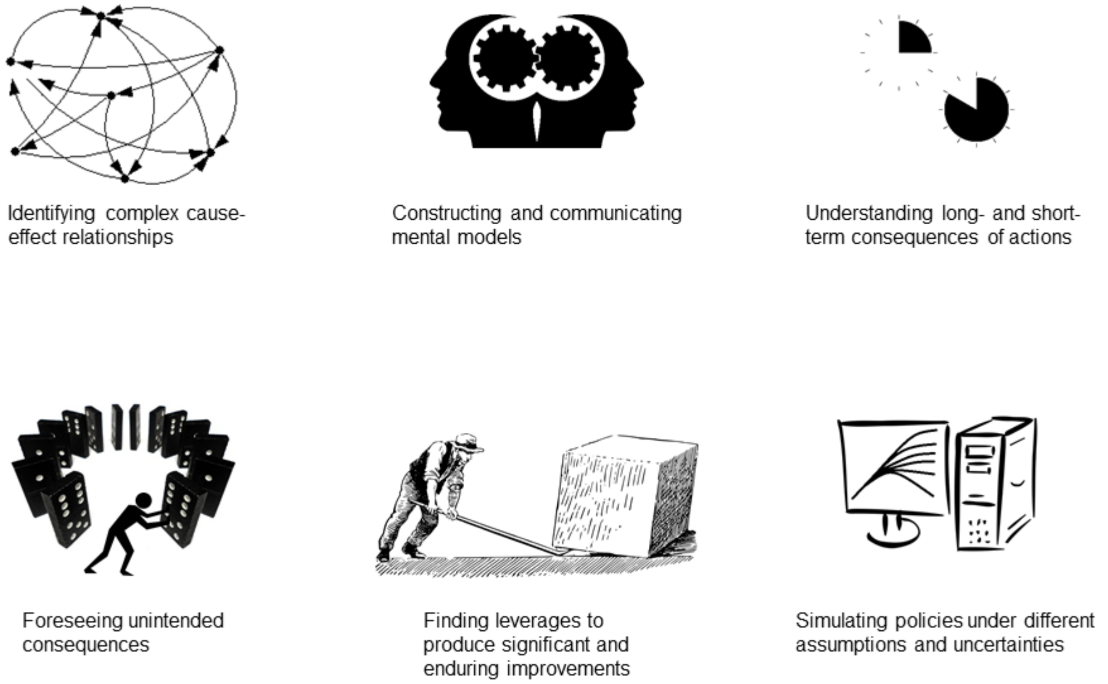

***Figure 4: Benefits of system dynamics. Modified from Benson and Marlin* [50].**

Modeling interconnections of system elements and identifying feedbacks are the foundations of system dynamics. By utilizing the model, it is possible to study the consequences of actions in time. Understanding the timing of consequences helps decision makers to avoid weighting short-term consequences over long-term consequences. In addition, understanding short- and long-term consequences enables managers to schedule a series of actions to achieve a long-term optimum, and to create relevant metrics to follow the progress towards the optimum. Moreover, a good model helps decision makers to recognize and foresee unintended consequences. Unintended consequences are typically distant in time and space [4, p. 11], which makes them difficult to foresee without enhancing the understanding of long-term consequences by modeling.

System dynamics modeling helps in finding relevant systemic leverages to achieve the goals. Finding leverages refer to identifying feedbacks that can be utilized to transfer the system towards the desired direction. Self-reinforcing feedbacks can be utilized by perturbing the system in the right place to trigger the favorable self-reinforcing behavior of the system. Balancing feedbacks instead enables keeping the system in current state and thus balancing feedback can be utilized to prevent undesired perturbations. To continue the snowball example in Section 3.1: pushing the snowball to the right direction, the snowball will roll down the hill with increasing velocity and size. Similarly continuing the spring example: if a door is attached with a mechanical spring, the balancing behavior of the spring will automatically close the door after one has opened it. As introduced in these two examples, system dynamics can be utilized to find leverages to produce significant and enduring improvements.

Benefits of system dynamics presented above are possible to achieve by conceptual modeling. However, a numerical model has even more potential to improve holistic understanding because simulations enable assessing quantitatively consequences of actions. In numerical simulation the model structure is applied comprehensively, equally, and without implicitly adding elements and behavior from mental models. Therefore, simulations show explicitly the dynamic consequences of actions under assumptions and system structure presented in the simulation model. Even though the simulation model would be very similar with the conceptual model, simulations may help to improve the understanding by discovering unintended consequences or by presenting more clearly the dynamic behavior of the system. Simulations also enable convenient study of policies and dynamic behaviors under different assumptions and uncertainties as well as convenient use of optimization tools in policy design.

4. THE MODEL

Finnish healthcare system will confront a major challenge of workload in near future due to a demographic change in Finnish society. As the society ages, demand for caring services increases. According to social and health strategy of Ministry of Social Affairs and Health (STM) [2, p. 11-12], the focus of elderly politics is put on preventive and early interventions at customers' natural residential environment. In other words, social and healthcare services should be offered to customers at their homes. This means that the challenge of workload will be especially visible in home care services.

Aging is a global megatrend. In 2015, there were 77 per cent more people aged 80 years old or older than in 2000, and projections indicate that there will be another 61 per cent increase by 2030. By 2050, the number of people aged 80 years old or over is projected to more than triple compared to 2015. [51, p. 9] Statistics of the National Institute for Health and Welfare (THL) [52] report that a similar demographic change has occurred also in Finland. For example, the proportion of people over 85 years old in 2016 in Finland was exactly twice that in 1995. Furthermore, projections of Statistics Finland indicate that the proportion of people over 85 years old will be in 2040 even more than 4.5 times bigger than in 1995 [53]. Figure 5 illustrates the realization and the projection of demographic change in Finland from 1995 to 2040.

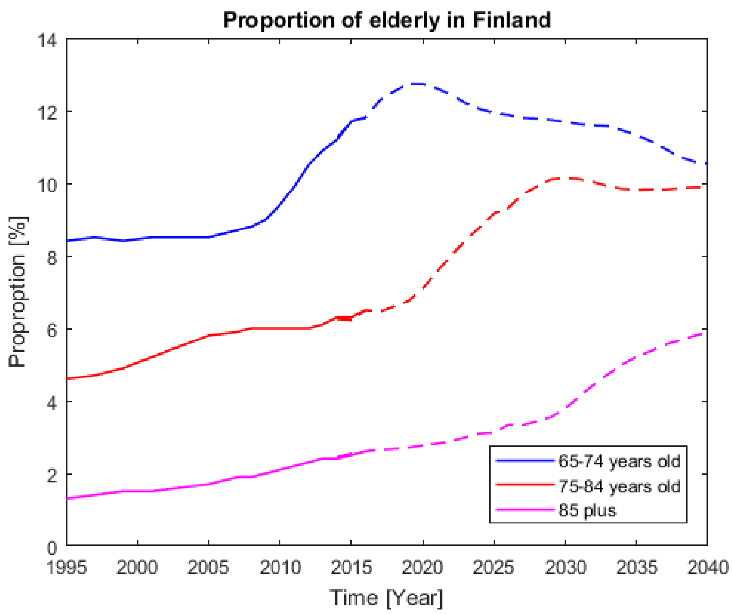

***Figure 5: Proportion of elderly people in Finland. Realization from years 1995 to 2016 and projection from year 2014 to 2040. Realization of elderly proportion is illustrated as a solid line and projections are illustrated as dashed lines. Sources: THL's Sotkanet database* [52] *for realizations and Statistics Finland's StatFin database for projections* [53].**

The proportion of elderly people in the society is an important metric because it describes how much there are potential customers compared to potential service providers and financers. If the whole population would grow at the same pace it is very likely that the increased number of customers would not cause a workload problem. In the scenario of equivalent growth, it would be only a matter of scaling up the operations. For these reasons, the root cause of the problem is that the proportion of elderly people is growing rapidly and the growth is even expected to increase in future.

Despite the huge growth of elderly people in society, the workload challenge in home care could be solved by increasing the home care resources. Adequate resources would allow home care organizations to recruit more employees to fulfill elderlies' demand for care services. Unfortunately, Finland has suffered many economically challenging years after the financial crisis in 2008, which has led to a large sustainability gap in the government finance [54]. The sustainability gap has been financed by loaning [55, p. 11], but the government has announced that their aim is to balance the government budget by 2021 [55, p. 15]. Therefore, resource adequacy is another aspect to the workload problem.

The third aspect to the problem is the governance of the public elderly care in Finland. Currently there are many operating organizations in elderly care. Hospitals, institutional care providers, home care organizations and private care providers are examples of operating units in the field of elderly care. The problem is that every operating unit is trying to optimize their own operations even in situations where the actions of one unit will have consequences on the field of another unit. The subsystem optimization combined with resource limitation reduces the flexibility of the elderly care because these policies might prevent actions and operations that could be justified by holistic reasoning. Furthermore, subsystem thinking will hardly lead achieving the global optimum of elderly care even in the context of public elderly care.

The problem articulation was formed iteratively as this thesis project advanced. Multiple home care organizations were visited to gather insights and data, to test assumptions, and to validate results. Iterative working method modified the problem articulation and dynamic hypothesis, therefore, methods to tackle the problem. Initially, before contacting the case organizations, the dynamic hypothesis, in brief, was that the financial restrictions are driving elderly care to allocate the most of resources to the actual hands on caring task. This would not allow enough engagement activities, science education nor thinking of ethical responsibility which would, in a long run, erode the service quality of the home care. However, discussions with case home care organizations identified that at the moment the most important dimension of responsibility is the governance.

The following subsections describe the updated dynamic hypothesis and formulation of the simulation model. The model is presented component by component to improve readability of the functionality as well as to enhance the understanding of the system behavior.

4.1 Customers

Aging society will increase people in need of caring services. This study focuses on home care services, therefore, the boundaries of the model is set around the home care. However, in order to understand holistically the consequences of actions in home care, we have to consider customers also after they have left the home care service. An assumption is that as people get older a need for caring services arise, and the first care provider will be a home care organization. Another assumption is that customers in home care will eventually flow to an institutional care unit. In other words, as people are requiring caring services due to aging they will come to the system and become customers of a home care provider. After a while, every home care customer will become a customer of an institutional care provider. Eventually due to aging, customers exit the system under inspection. Figure 6 visualizes the borders of the model.

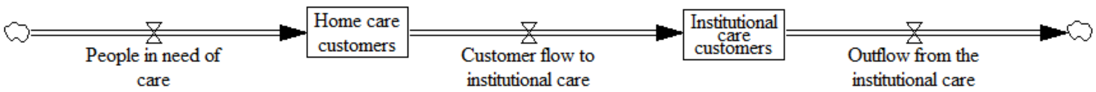

Figure 6: Model borders for customers. Cloud shaped figures indicate the borders of the model.

An estimation for the number of people in need of caring services in case municipalities was found by regression modeling. An initial assumption was that the size of three elderly age groups (65 to 74 years old, 75 to 84 years old and over 85 years old) would explain the number of customers in home and institutional care. Nevertheless, three regression models were created to find out an appropriate number of age groups explaining the number of people in need of elderly care services. Data from THL's database [52] covering every Finnish municipality was used in the regression modeling.

By utilizing the regression analysis to foresight the people in need of elderly care services, we accept an assumption that the relationship between the demographic variables and the dependent variable will in future be the same as it was in the historical data. The results of the regression analysis are shown in Table 3. Figures 7-9 present comparisons of the regression results to the historical data of the municipalities in which the case home care organizations are operating and to aggregated data of all Finnish municipalities.

Table 3: Results of regressions modeling to explain the number of people in need of care. Results for three different regression models are presented, where g_i is people aged 65 to 74 years old, z_i is people aged 75 to 84 years old, and x_i is people aged over 85 years old. Regression method is Ordinary Least Squares and the data includes 3345 observations.

1. One explaining variable			
Regression model:	$y_i = \beta_1 + \beta_2 x_i + \varepsilon_i,$		
Variable	**Value**	**Std error**	**t-statistic**
β_1	23.7880	2.2845	10.4129*
β_2	0.9167	0.0023	398.5551*
R^2	0.9794		
Adjusted R^2	0.9794		
2. Two explaining variables			
Regression model:	$y_i = \beta_1 + \beta_2 z_i + \beta_3 x_i + \varepsilon_i$		
Variable	**Value**	**Std error**	**t-statistic**
β_1	6.3936	2.0553	3.1109*
β_2	0.1693	0.0051	32.8823*
β_3	0.4787	0.0135	35.5322*
R^2	0.9844		
Adjusted R^2	0.9844		
3. Three explaining variables			
Regression model:	$y_i = \beta_1 + \beta_2 g_i + \beta_3 z_i + \beta_4 x_i + \varepsilon_i$		
Variable	**Value**	**Std error**	**t-statistic**
β_1	5.2518	2.0594	2.5502*
β_2	-0.0156	0.0030	-5.1590*
β_3	0.1928	0.0069	28.0858*
β_4	0.4880	0.0135	36.0377*
R^2	0.9845		
Adjusted R^2	0.9845		

*Statistically significant at the confidence level of 95 %

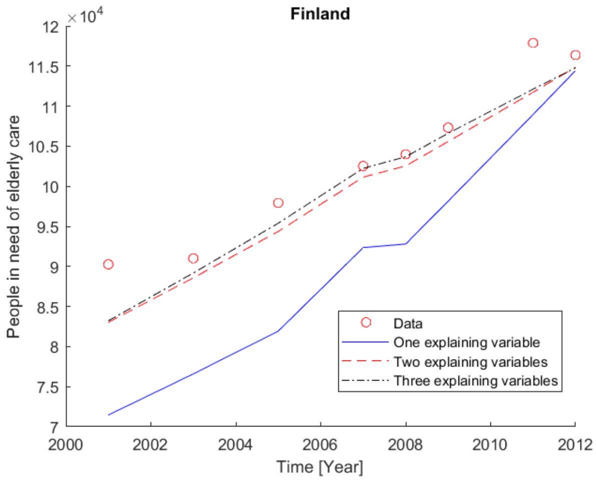

Figure 7: Comparison of regression estimates with historical aggregated data from all Finnish municipalities.

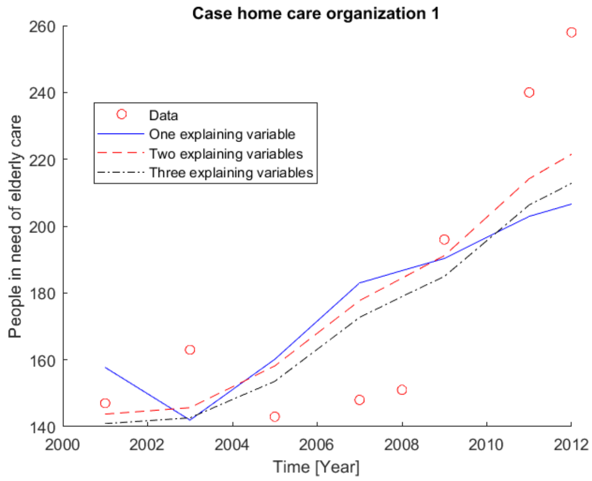

Figure 8: Comparison of regression estimates with historical data from the municipality of the first case home care organization

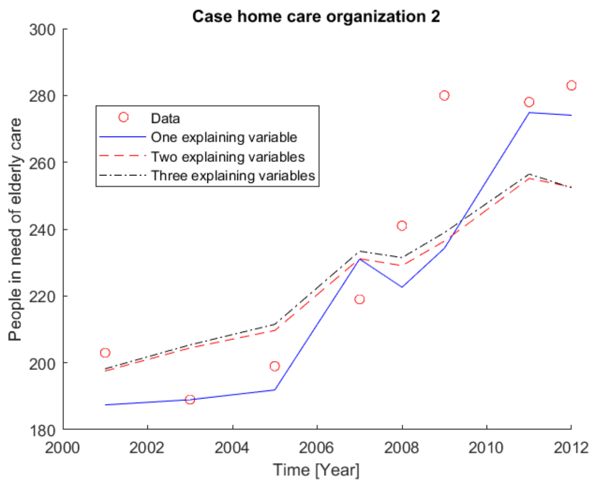

Figure 9: Comparison of regression estimates with historical data from the municipality of the second case home care organization

Regression modeling (Table 3) shows that all estimated regression coefficients are statistically significant in the confidence level of 95 per cent. Furthermore, every regression model provides very good coefficients of determination, which means that every regression model is well explaining the variation of the observed dependent variable. Because regular and adjusted coefficients of determination are basically the same in every regression they does not give much help to us for selecting the best regression model. However, the third regression model has a negative coefficient for the second explaining variable that represents the people aged 65 to 74 years old. This is illogical because it would mean that the more people aged 65 to 74 years old live in the society the less people are in need of elderly care services. Therefore, let's discard the results of the third regression model. The first and the second regression models still produce rather similar results. Due to slightly better adjusted coefficient of determination and clearly better fit to aggregate data of Finnish municipalities in Figure 7, the second regression results are selected for the model.

The predicted number of people in need of elderly care services allows us to simulate the number of potential customers in future (Figure 10). Potential customers are the number of people in need of caring services subtracted by the current customers.

```
Potential customers = People in need of care -
     Regular home care customers - Institutional care customers
```
(1)

Potential customers become new regular customers of home care after a home care position is found for them. We assume that it takes 30 days to find a home care position after a need for elderly care services arises. The 30 days include the time for the person to contact service providers and the time service providers need for taking a new customer. Data from the case home care organization (Appendix B) reveals that their customers are using home care services 1300 days on average. After that the customers will need more intensive caring forms. An assumption is that all former home care customers will move to institutional care services. Therefore, regular home care customers accumulates the flow of new customers and the customer flow to institutional care[3]. Customer flows are formulated as first-order processes. According to the Little's law[4], the first order outflows can be calculated from the stock value and the average delay time.

[3] The models are presented with minimal mathematical notation by naming the variables as they correspond in the simulation model. The INTEGRAL function denotes an accumulation:

$$\text{Stock} = \text{INTEGRAL}(\text{Inflow} - \text{Outflow}, \text{Initial stock})$$

is equivalent to

$Stock_T = \int_{t_0}^{T}(Inflow - Outflow)dt + Stock_{t_0}$.[56] p. 324

[4] Little's law: If the system is in equilibrium, the outflow of a first-order delay is $O = \frac{S}{D}$, where S is the stock and D is the average delay time. [4] p. 423

```
Regular home care customer  = INTEGRAL(New customers -
      Customer flow to institutional care,
      Initial home care customers)
```
(2)

```
New customers = Potential customers/
      Time to find a home care position
```
(3)

```
Customer flow to institutional care = Regular home care customers/
      Average time in home care
```
(4)

The customer flow to institutional care is assumed to be a function of the health of home care customers. Unfortunately, there is not enough data available for a statistical analysis of this effect, but we assume that the average time in home care is determined by the standard time and the squared health of customers.

$$\text{Average time in home care} = \text{Standard time in home care} \cdot \text{Health of customers}^2 \quad (5)$$

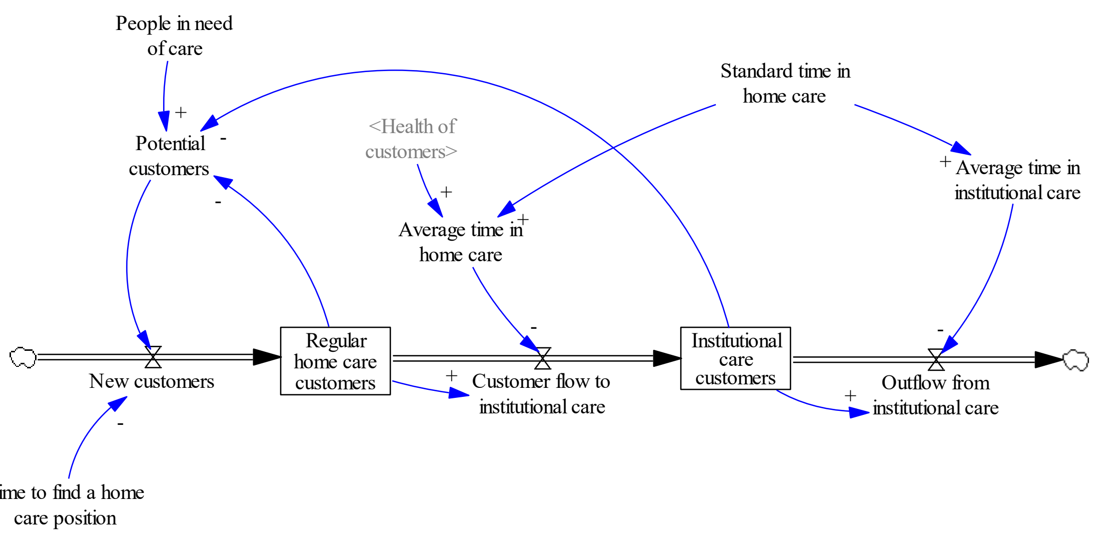

Figure 10: Customer flow in elderly care. Black arrows represent a flow from one stock to another. Blue arrows represent an influence between variables. Plus signs at the head of blue arrows represent positive influences and minus signs represent negative influences.

From THL's database we can calculate an initial proportion of institutional care customers compared to home care customers. At our initial simulation time in 2014 the proportion of institutional care customers was 63 per cent of customers in home care. The initial time for simulation was selected to be 2014 because the most recent population forecast of Statistics Finland is from the year of 2014 (Appendix C). Knowing the relative number of customers in home and institutional care enables solving the standard time customers are spending in institutional care that balances the initial state of the model. The model is balanced at the beginning of simulation to facilitate testing. The solved time in institutional care with current settings is approximately 813 days. According to interviews with case home care organizations, 813 days in institutional care was a realistic time.

```
Institutional care customer =                                        (6)
      INTEGRAL(Customer flow to institutional care -
      Outflow from institutional care,
      Initial institutional care customers)

Outflow from institutional care = Institutional care customers/     (7)
      Average time in institutional care
```

In addition to regular customers, home care organizations serve also temporary customers (Figure 11). Temporary customers are typically rehabilitation customers from acute illnesses or accidents. Therefore, the number of temporary customers are assumed to follow a normally distributed random variable and the size of population. Another assumption is that if the quality of care in home care decreases, fewer potential temporary home care customers can be treated properly in home care. As a result, a part of potential temporary home care customers need outpatient care to recover.

```
People in need of temporary care =                                   (8)
      Random variable for temporary customers·Population forecast

Temporary home care customers needing outpatient care =              (9)
      IF THEN ELSE(Quality of care > 1, 0, Quality of care^2 -
      2·Quality of care + 1)

Net change of temporary home care customers =                       (10)
      (People in need of temporary care·(1 -
      Temporary home care customers needing outpatient care) -
      Temporary home care customers)/
      Time of changes in temporary customer base
```

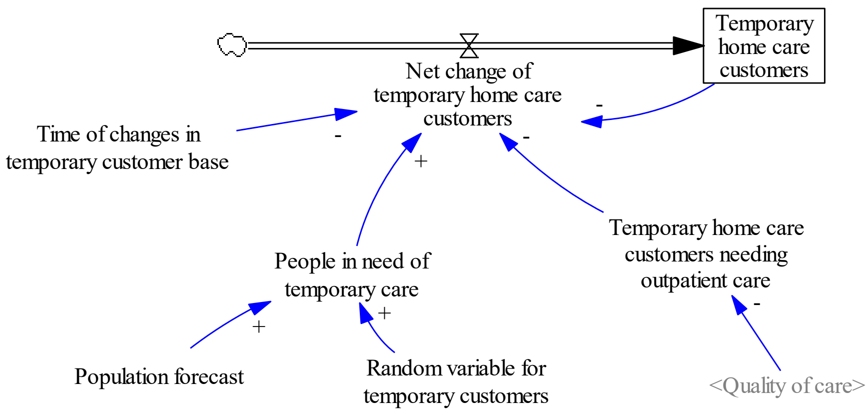

Figure 11: Temporary customers in home care

The mean and standard deviation for the random variable are calculated from the data of a case home care organization (Appendix B). The year 2015 was discarded from the data due to a big drop of temporary customers. Therefore, years 2016 and 2017 are assumed to be more representative in this future oriented study. In this setting the mean and the standard deviation of temporary customers are 24.43 and 6.59 respectively. However, in testing and validation phase we will test the effect of taking also the data from year 2015 into account.

4.2 Home care service

Home care services supports independent living at home by exercising home visits (Figure 12). The number of required home visits depends on: the number of customers, health of customers, and technology to support home care operations. Technology refers to automatic medicine dispenser robot that is the main offering of the case technology company. Case home care organization's data (Appendix B) suggests that a standard regular home care customer needs 1.1 home visits per day. It is assumed that the number of home visits needed per customer is directly proportional to their health. If the health of a customer decreases the need for home visits increases. Therefore, the number of home visits needed per regular home care customer is the standard number of visits needed per customer divided by the health of customers. However, it is assumed that a customer needs maximum eight visits a day. The health is a nominal variable that is standardized to be one in the initial state of the simulation. The determination of customers' health is presented in Section 4.6.

```
Needed visits per customer =                                        (11)
      min(Standard number of visits needed per customer/
      Health of customers, Max number of visits per customer)
```

Temporary home care customers need the home care service for different reasons than regular customers, which implies that temporary customers may need different number of home visits than regular customers. According to data from a case home care organization (Appendix B), a standard temporary home care customer requires approximately two home visits per day. Due to the short term customership of temporary customers, the automatic medicine dispenser robots are assumed to be used only with regular customers. An assumption is that the automatic medicine dispenser robot can replace 50 per cent of home visits from suitable customers.

```
Home visits needed = (Regular home care customers -                 (12)
      Number of automatic medicine dispensers·
      Proportion of automated visits)·
      Needed visits per customer + Temporary home care customers·
      Needed visits per temporary customer
```

The need for home visits increase the service backlog in home care, and exercised home visits decrease the backlog. The target service delivery delay is one day because the inflow to the home care service backlog represents home visits needed in a day. The more home visits there are to exercise the bigger the desired service capacity would be. The size of the desired service capacity, however, depends also on the standard time per visit as well as the standard workday. An employee in a case home care organization exercises on average 5 home visits per day (Appendix B). The standard workday in home care is approximately 5 hours, if the workday is equalized to real daily working hours. The equalization means that the standard workday must be subtracted by weekends and holidays Eq. (16). In Finland, there are two day weekend, employees earn 38 holidays in a year[5], and there are approximately ten public holidays per year. The standard workweek in home care without equalization would be 38 hours and 45 minutes[6].

```
Home care service backlog =                                              (13)
      INTEGRAL(Home visits needed - Home visit completion rate,
      Home visits needed·Target delivery delay)

Standard time per visit = Standard workday/                              (14)
      Standard visits per day

Desired service capacity = Home care service backlog·                    (15)
      Standard time per visit/(Standard workday·
      Target delivery delay)
```

$$\text{Standard workday} = \frac{38.75\text{ h}}{7} \cdot \frac{365\text{ d} - 38\text{ d} - 10\text{ d}}{365\text{ d}} = 4.8077\text{ h} \quad (16)$$

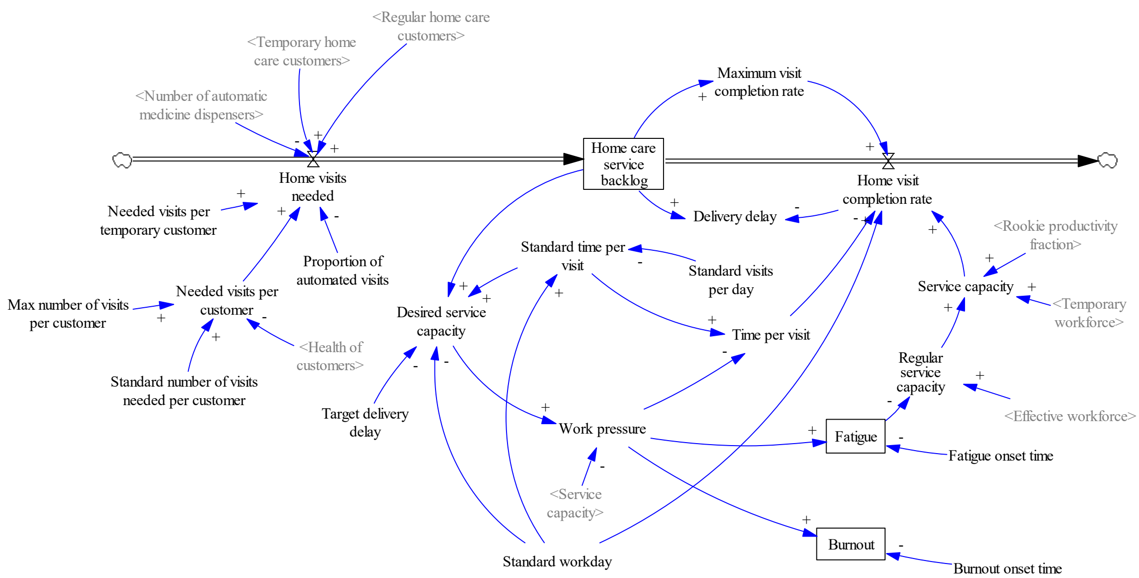

Figure 12: Home care service

If the desired service capacity is bigger than the actual service capacity, either more employees should be recruited or the productivity should be improved in order to meet the

[5] The length of the workday is not important in the dynamics, but helps to form an understanding of the situation. Therefore, let's use 38 days as a number of annual earned holidays, which is the maximum number in the collective agreement of Finnish public employees. More information about the collective agreement in Finnish can be found from https://www.kt.fi/sopimukset/kvtes/2017/luku-4-vuosiloma.

[6] The collective agreement in Finnish https://www.kt.fi/sopimukset/kvtes/tyoaika.

target delivery delay. The delivery delay cannot be higher than one day because many tasks in home visits are time sensitive. For example, giving diabetes medication is a highly time sensitive task of home care. It is assumed that the home care organization can organize the home visits to fulfill time demands of particular customers, if there is enough service capacity to achieve the target delivery delay. According to the interviews with case home care organizations, they are able to increase their workforce only once a year, and even then provided a budget that determines the authorized employee resources for the next year. This means that in practice the gap between desired and the actual service capacity must be fulfilled by the change of working practices. Interviews with the case home care organizations revealed that shortening the length of home visits is the only method to increase their home visit completion rate at a short term. Therefore, the number of home visits in the service backlog and the service capacity determine the work pressure that affects the length of home visits.

```
Work pressure = Desired service capacity/Service capacity                (17)

Time per visit = Standard time per visit·                                (18)
      Effect of work pressure on time per visit

Effect of work pressure on time per visit = f(Work pressure)             (19)
```

The effect of work pressure on time per visit is assumed to be similar with the Oliva & Sterman's [56, p. 331-332] estimate from a field study of retail lending operations in a UK bank (Figure 13). According to interviewees in the case home care organizations, the estimate is applicable also to home care operations in Finland.

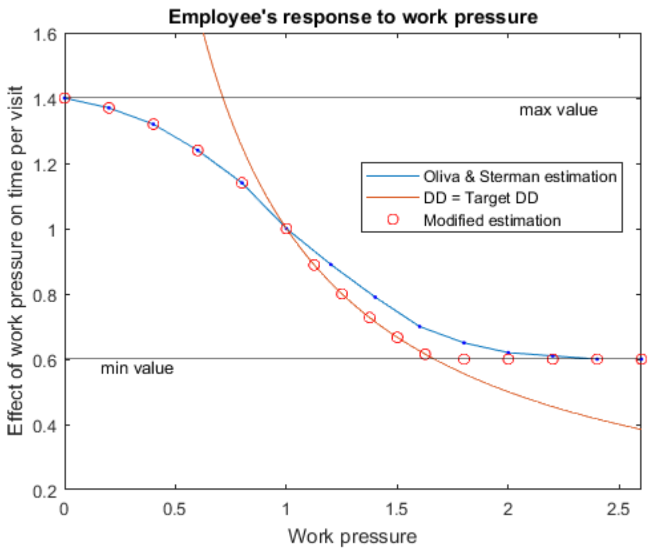

Figure 13: The effect of work pressure on time per home visit. DD represents delivery delay. Work pressure and its effect on time per visit are both dimensionless variables.

Shortening the home visits enable home care providers to meet the target delivery delay. However, there are limits for the effect of corner cutting. The time allocated per home visit cannot be lower than 60 per cent of the standard time (Figure 13). If the available time per home visit was lower, there would not be enough time for traveling to every location and exercising the necessary tasks in the quickest possible way. On the other hand, the time per visit will not take longer than 140 per cent compared to the standard time even if the work pressure would approach zero. If there was more time available per home visit, employees would take longer breaks. Figure 13 also shows that in Oliva & Sterman estimate the effect of work pressure on time per visit is not strong enough to meet the target delivery delay if the service capacity is lower than the desired service capacity (i.e. work pressure is over one). However, interviewees in case home care organizations strongly emphasize that every planned home visit needs to be exercised during the shift. Therefore, the Oliva & Sterman estimate is modified to this context at the area where the effect of the work pressure is lower than one but higher than the minimum value.

In addition to time per home visit, work pressure has an effect on fatigue and burn out. The effect of work pressure on fatigue and burnout is assumed to be similar with Oliva & Sterman [56, p. 331-333] estimate from a UK bank. Oliva & Sterman estimate that work pressure increases working hours of the workforce (Figure 14), which leads to a fatigue and burnout. In home care context, work pressure does not increase working hours but, according to the discussions with case home care organizations, the effect of work pressure on fatigue and burnout can still be assumed to be similar with Oliva & Sterman estimation.

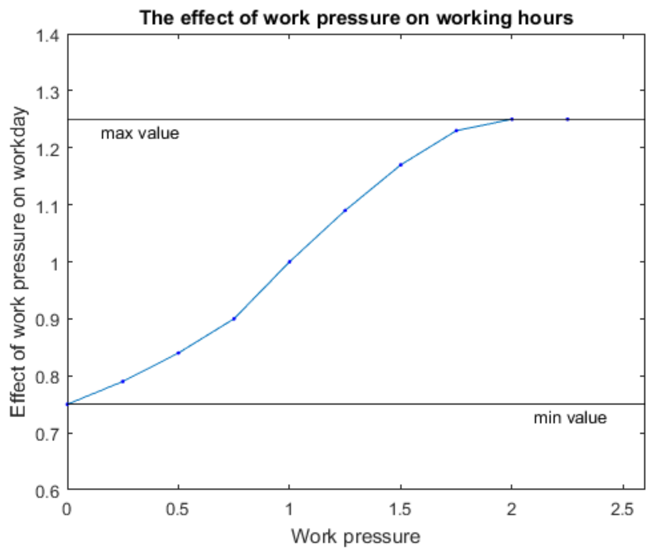

Figure 14: The estimation for the effect of work pressure on workday in a British bank. Used as the effect of work pressure on fatigue in the Finnish home care context. Work pressure and its effect on workday are both dimensionless variables.

Oliva & Sterman's estimate about the effect of work pressure on workday is used in this context as an effect of work pressure on fatigue. Note that the effect of work pressure on fatigue also has, similarly with the effect on time per visit, saturation points at both ends of work pressure. Fatigue is a natural effect of human body and mind that develops under the strain and dissipates over time. Thus, the fatigue can be modeled as an exponentially weighted moving average[7] of past work intensity [56, p. 333]. Fatigue onset time describes the considered time span of the past that has an effect on the level of fatigue. Thus, the longer the fatigue onset time the longer it takes for the employees to feel fatigue and, on the other hand, to recover from strain. Work pressure is assumed to have precisely the same effect also on burnout, except that the burnout onset time is longer than the fatigue onset time. Fatigue and burnout onset times are set to be three weeks and a year respectively, similarly with the Oliva & Sterman model[8].

```
Effect of work pressure on fatigue = f(Work pressure)                (20)

Fatigue = SMOOTH(Effect of work pressure on fatigue,                 (21)
      Fatigue onset time)

Burnout = SMOOTH(Effect of work pressure on fatigue,                 (22)
      Burnout onset time)
```

Fatigue reveals the negative effect of the work pressure on home care service as it decreases the productivity of the workforce. Thus, the effect of fatigue on productivity is a decreasing function (Figure 15). There is no data available from the actual context about the effect of the fatigue on productivity. Therefore, let’s use the same model as Oliva and Sterman [56, p. 333]. According to case home care organizations, this effect is plausible also in home care context. However, the reader should notice that Oliva and Sterman have determined in their article that the fatigue saturates to 0.75 at the one end and to 1.25 at the other end (see Figure 14). Thus, only the corresponding range of productivity in Figure 15 is relevant for the modeling.

---

[7] Output = SMOOTH(Input, Average Time) denotes first order exponential smoothing of the input with a mean delay of the Average Time [56] p.333.

SMOOTH function is equivalent to:

$\hat{X}(t) = \alpha X(t) + (1-\alpha)\hat{X}(t-1)$,

where w is the smoothing factor, $X(t)$ is the actual value of the input variable and t is time [58]. The smoothing factor is between 0 and 1 and is determined by:

$\alpha = 1 - \exp\left(-\frac{\Delta t}{\tau}\right)$,

where Δt is the time step and τ is the time constant of the exponentially weighted moving average function denoted as Average Time in SMOOTH function. [4] p. 430

[8] http://iops.tamu.edu/faculty/roliva/research/service/handbook/

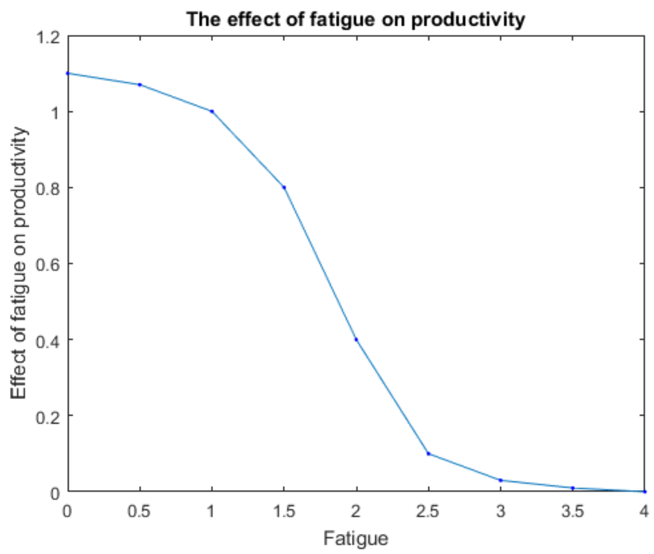

Figure 15: The effect of fatigue on productivity. Fatigue and its effect on productivity are both dimensionless variables.

Three types of employees of a home care organization are included in the model: rookie employees, experienced employees, and temporary employees. Rookie and experienced employees form the regular workforce that exercises home visits. It is assumed that temporary employees change often enough that the effect of fatigue only affects the productivity of the regular employees. Effective workforce is the regular employees adjusted by productivity. The effective workforce will be explained in the next section.

```
Effect of fatigue on productivity = f(Fatigue)
```
(23)

```
Regular service capacity = Effective workforce·
      Effect of fatigue on productivity
```
(24)

Temporary employees is assumed to have the same productivity with the rookie employees. The assumption is justified if temporary employees are not staying in the organization longer than the assimilation time of rookie employees to become experienced ones, and if the same professionals are not hired as temporary employees multiple times in a short period of time. Under these assumption service capacity of the home care and the home visit completion rate are presented in Eqs. (25) and (26). The maximum visit completion rate is simply the number of home visits planned to be exercised in one day (i.e. home care service backlog). According to the Little's law, the average delivery delay of home care service can be calculated from the information of home care service backlog and home visit completion rate.

```
Service capacity = Regular service capacity +
      Temporary workforce·Rookie productivity fraction.
```
(25)

```
Home visit completion rate = min(Service capacity·
      Standard workday/Time per visit,
```
(26)

```
      Maximum visit completion rate)
```

```
Maximum visit completion rate = Home care service backlog        (27)
```

```
Delivery delay = Home care service backlog/                      (28)
      Home visit completion rate
```

If we only consider the short time period and the task completion rate, the relative effect of work pressure on time per visit compared to its effect on productivity determines the organization's capability to balance the service backlog and to meet the target delivery delay. If the work pressure has a larger effect on time per visit than on productivity, the organization is able to meet the target delivery delay by cutting corners.

4.3 Regular workforce

Previous section introduced the three types of employees in home care. This section focuses on the regular workforce (Figure 19). Regular workforce includes rookie and experienced employees that are continuously working for the home care organization. It is assumed that the home care organization can only hire rookie employees because the new employees probably lack job-specific knowledge and almost certainly lack firm-specific knowledge. Nowadays, nurses in home care must have extensive firm-specific knowledge, primarily because they need to deal with a multitude of IT-systems resulting from the ongoing digitalization. Another assumption is that all employees leaving the organization are experienced. This assumption is supported by case home care organization's data (Appendix B) that shows that only few employees leave the organization annually, and retirements represent a large portion of those few who quit. More specifically, the data shows that an average annual quit fraction of the case home care organization is 5 per cent. Discussions with the case home care organizations suggest that two months is a good approximation for the time it takes for a rookie employee to become an experienced one. Figure 16 presents the model for regular workforce.

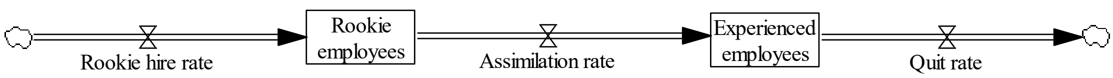

Figure 16: Basic structure of regular workforce.

According to the interviewees in case home care organizations, they have strict budget constraints that allow them to hire new employees only once a year when the budget for the next year have been accepted. At other times, home care organizations can only replace the employees that have left the organization. Figure 17 shows the key elements related to employee recruitment. Affordable number of employees can be calculated by dividing the employee budget by the estimated cost of an employee. The cost per employee is estimated from a case home care organization data (Appendix D). The estimated cost per employee is 47 000 € per year.

```
Affordable workforce = Employee budget/
      Estimated cost per employee
```
(29)

The authorized workforce, however, is also dependent on the desired workforce. Discussions with the case home care organizations revealed that home care managers are not only staring at the numbers in the budget but also sensing the operational environment. There was an example of a retirement situation, when the budget would have allowed hiring a replacement for the retiring nurse but the home care manager decided to continue with fewer nurses, because the workload in the home care was still moderate after the retirement. It is assumed that it takes one week for the manager to perceive the changes of efficiency of the workforce. Furthermore, an assumption is that managers use two month to deliberate the required adjustments in the service capacity in order to meet the desired service capacity, Eq. (15). A rather long deliberation time is assumed due to a pressure of cost savings in healthcare in Finland. The outcome of that deliberation is the desired workforce.

```
Perceived employee effectiveness = SMOOTH(Service capacity/
      Total workforce, Time to perceive productivity)
```
(30)

```
Desired workforce = SMOOTH(Desired service capacity/
      Perceived employee effectiveness,
      Deliberation time for workforce adjustments)
```
(31)

```
Authorized workforce = min(Affordable workforce,
      Desired workforce)
```
(32)

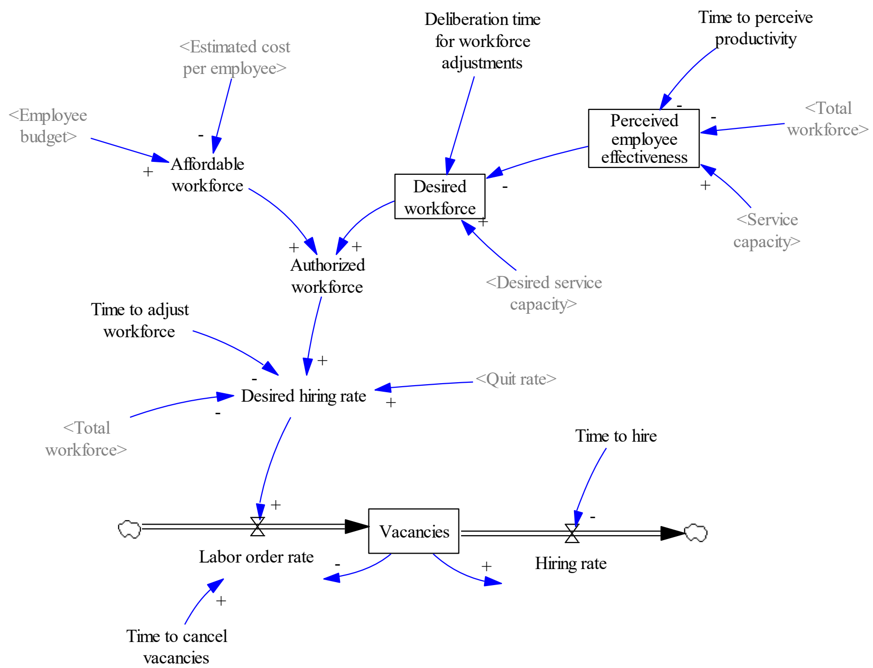

Figure 17: Employee recruitment

The desired workforce and the budget constraint define the authorized workforce. It is assumed that after the authorized workforce is known it takes still one week for the organization to set the desired hiring rate. Achieving the authorized workforce requires also taking the quit rate of employees into account in desired hiring rate. If the desired hiring rate is smaller than the number of currently open vacancies, the home care is assumed to be able to quickly cancel the excess vacancies. Thus, the time to cancel vacancies is set to be only one day. The cancellation of vacancies is assumed to follow the dynamics of a first-order system. Therefore, Little's law indicate that the possible vacancies cancellation rate is the listed vacancies divided by the time to cancel vacancies. Because the desired hiring rate may be negative but still bigger than the possible vacancies cancellation rate, the labor order rate must compare the desired hiring rate to the possible vacancies cancellation rate, Eq. (35).

```
Desired hiring rate = (Authorized workforce - Total workforce)/
      Time to adjust workforce + Quit rate
```
(33)

```
Vacancies = INTEGRAL(Labor order rate - Hiring rate,
      Desired hiring rate·Time to hire)
```
(34)

```
Labor order rate = max(Desired hiring rate, -Vacancies/Time to
      cancel vacancies)
```
(35)

After the vacancies have been created, potential employees will apply to the open positions. The time to recruit a new employee is assumed to be 60 days. The time is the accumulated length of every task related to the recruiting process. For example, going through applications, selecting promising candidates, interviewing candidates, selecting the employee, and the time the selected employee needs for taking the job. According to the interviews with the case organizations, two months was considered as a realistic time for recruiting a new employee.

```
Hiring rate = Vacancies/Time to hire = Rookie hire rate
```
(36)

Assimilation rate and the quit rate are modeled as first-order flows. Thus, assimilation rate is the rookie employees divided by the assimilation time. The assumption was that only experienced employees leave the organization but the data from a case home care organization (Appendix B) does not make a distinction between rookie and experienced employees. Therefore, the quit rate is the total workforce divided by the quit fraction.

```
Assimilation rate = Rookie employees/Assimilation time
```
(37)

```
Quit rate = Total workforce·Quit fraction
```
(38)

Rookie and experienced employees form the effective workforce in home care. According to the case home care organizations, rookies are working almost immediately side by side with experienced employees but it can be assumed that rookie employees are 20 per cent less efficient than the experienced employees. The number of sick leave days in a case home care organization (Appendix B) reveals that in a standard situation approximately 10 per cent of employees are on a sick leave. Illness recovery time is assumed to be 14 days because a common flu can last up to 14 days[9]. Some illnesses may recover faster but on the other hand there are also accidents and other more severe illnesses that require much longer recovery time. By the information of the standard proportion of employees on sick leave and the standard illness recovery time, we are able to calculate the standard illness occurrence rate.

```
Standard illness occurrence rate =
      Standard proportion of employees on sick leave/
      Standard illness recovery rate
```
(39)

It is assumed that hurry and long lasting high work intensity increase the number of sick leaves. If nurses must hurry in order to meet the target delivery delay, accidents are more likely to happen. The term burnout refers in this document to the level of long term work intensity. If the level of burnout is high, employees must take time to recover that leads to sick leaves. Due to the lack of data, the effects of hurry and burnout on sick leaves are assumed to be quite simple (Figure 18). However, by leaving these effect out of the simulation would mean an assumption that they do not have any effect on sick leaves. The effect of burnout on sick leave is the same than used by Oliva & Sterman[10] to describe the quit fraction. It is assumed that employees with burnout will more likely take sick leaves than to quit in Finnish home care context.

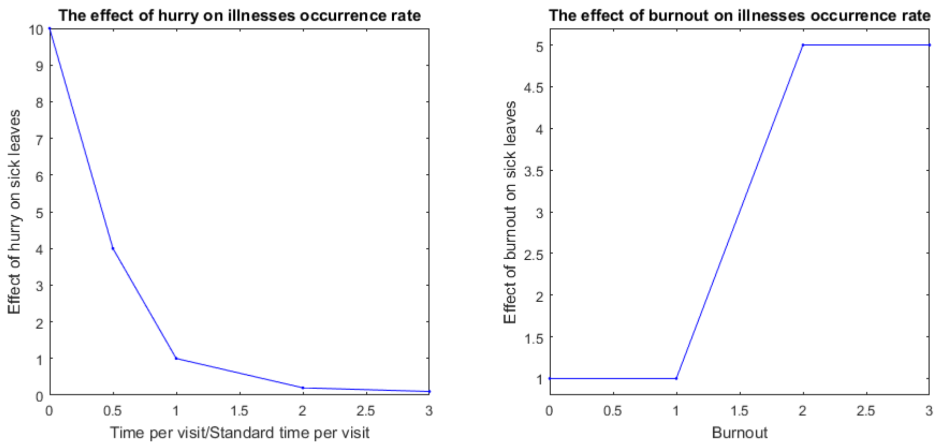

Figure 18: Effects of hurry and burnout on illnesses occurrence rate. Burnout and the effects are dimensionless variables.

The number of rookie employees, standard illnesses occurrence rate, and the effects of hurry and burnout define the number of rookie employees starting sick leaves Eq. (40). Rookie employees on sick leave is a stock variable Eq. (41) whose outflow is determined

[9] A detailed description about flu can be found in Finnish from http://www.terveyskirjasto.fi/terveyskirjasto/tk.koti?p_artikkeli=skl00011#s8
[10] http://iops.tamu.edu/faculty/roliva/research/service/handbook/

by the standard illness recovery time. The standard illness recovery time is assumed to be a first-order delay Eq. (42). Experienced employees on sick leave is modeled similarly.

```
Illnesses occurrence rate of RE = Rookie employees·                (40)
      Standard illness occurrence rate ·
      Effect of hurry on illness occurrence rate(
      Time per visit/Standard time per visit)·
      Effect of burnout on illness occurrence rate(Burnout)

Rookie employees on sick leave = Illness occurrence rate of RE -   (41)
      Illness recovery rate of RE

Illness recovery rate of RE = Rookie employees on sick leave/      (42)
      Standard illness recovery rate
```

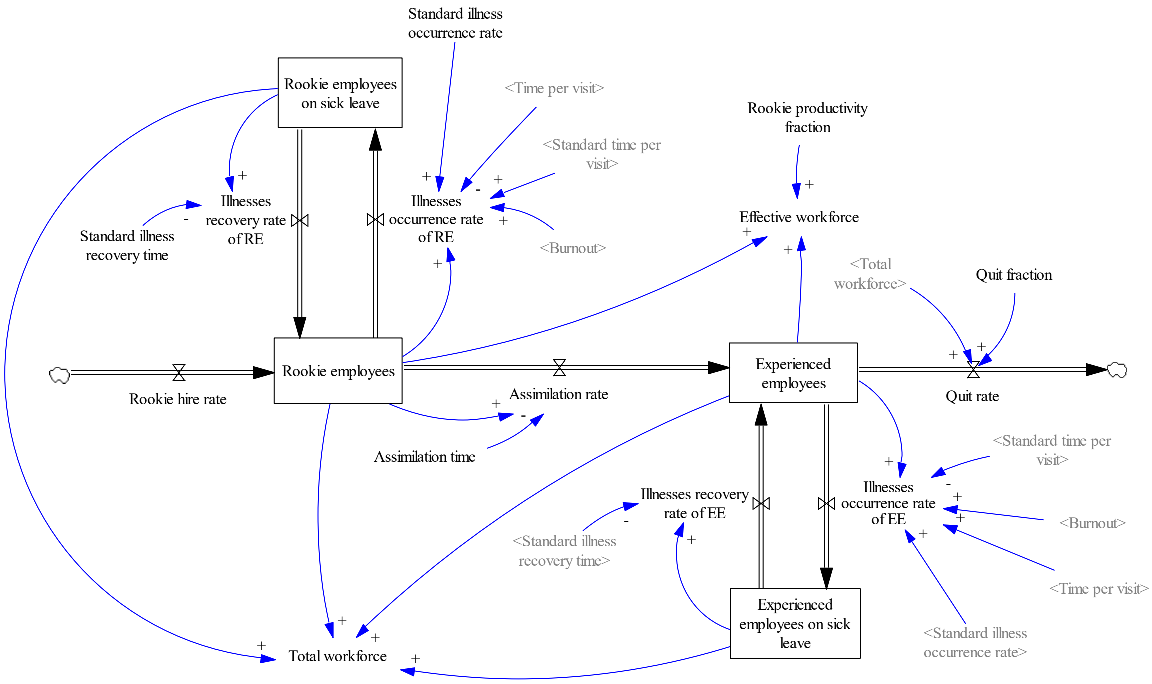

Figure 19: Regular workforce

The structures of employee recruitment (Figure 17) and regular workforce (Figure 19) show how all employees on the payroll, named as total employees, determine the hiring rate but the effective workforce is the adjusted number of employees that takes into account the productivity as well as sick leaves. Temporary workforce is used to compensate the employees on sick leave to preserve required number of effective workforce. The following section describes how temporary workforce is modeled in this study.

4.4 Temporary workforce

According to interviewees in the case home care organizations, due to strict employee budgets public home care providers have outsourced the reserve workforce to rental employee providers. The employee budget does not allow home care organizations to have enough reserved employees in case of sick leaves but the law obligates them to provide a certain service level for customers. Therefore, temporary employees are hired to compensate the decrease of the effective regular workforce caused by sick leaves (Figure 20).

An assumption is that temporary workforce is flexible and readily available. Thus, adjusting the temporary workforce is assumed to be an easy task that can be done during the day as the need arises. The net change of temporary workforce must compare employees on sick leaves to currently hired temporary workforce in order to achieve the desired number of temporary employees to compensate the reduced work contribution of the regular employees.

```
Net change of temporary workforce =
      (Rookie employees on sick leave +
      Experienced employees on sick leave/
      Rookie productivity fraction - Temporary workforce)/
      Time to adjust temporary workforce
```
(43)

```
Temporary workforce = Net change of temporary workforce
```
(44)

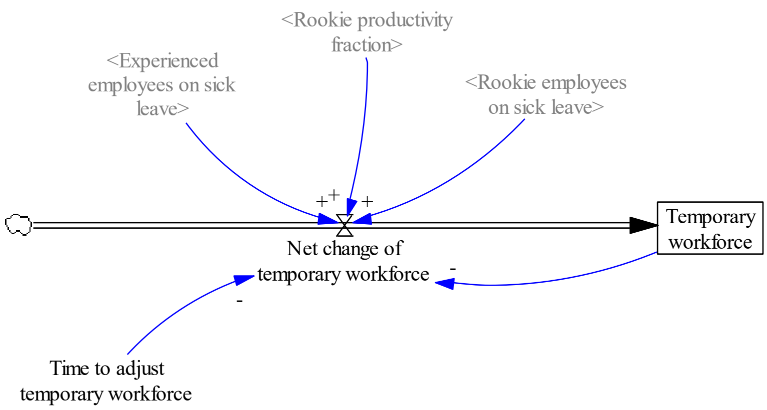

Figure 20: Temporary workforce

Temporary workforce is used to compensate the workforce on sick leave. The productivity of temporary employees, however, was assumed to be similar with rookie employees in the function of service capacity, Eq. (25) in Section 4.2. As a result, the productivity would be reduced, if the equal number of temporary employees was hired to compensate the experienced employees on sick leave. An assumption is that home care managers are aware of this productivity gap between experienced and temporary employees, which allows them to hire the right number of temporary employees to compensate the output of the regular employees on sick leave. Therefore, the number of experienced employees on sick leave is divided by the rookie productivity fraction in Eq. (43) to preserve a steady service level.

4.5 Technology

Technology seeks to improve productivity. An automatic medicine dispenser robot is an example of assistive technologies to improve the efficiency of home care service (Figure 21). The device is delivering the right medicine at the right time to the user as well as alarming and reminding the user to take the medicine. In addition, there is a software that enables alarms to caring personnel, for example, if the end-user has not taken the medicine from the device. However, the device is not monitoring if the end-user actually takes the medicine, and even though the device is easy to use it still requires some physical and cognitive capabilities from the end-user. Therefore, the automatic medicine dispenser robot is not suitable for every home care customer. The proportion of suitable customers is assumed to be 50 per cent. In addition, it is assumed that home care organizations are offering this service only for regular customers. For these reasons, the desired number of automatic medicine dispensers is the number of regular customers multiplied by the proportion of customers that would benefit from the technology.

```
Desired number of automatic medicine dispensers =
      Regular home care customers·
      Proportion of customers able to use the robot
```
(45)

Similarly to the employee recruitment, the budget constraints the use of technology. A monthly fee of the service, including the robot and additional services, is assumed to be 150 euros. The additional services include, for example, training of employees, the service for nurses to monitor the medicine adherence, and technical support. The fraction of budget used to technology determines the affordable number of automatic medicine dispenser robots. The actual number of automatic medicine dispenser robots is therefore the minimum value of desired and affordable number of devices.

```
Affordable number of automatic medicine dispensers =
      Budget·Max fraction of budget allocated to technology/
      Annual fee of automatic medicine dispensers
```
(46)

```
Number of automatic medicine dispensers =
      min(Desired number of automatic medicine dispensers,
      Affordable number of automatic medicine dispensers)
```
(47)

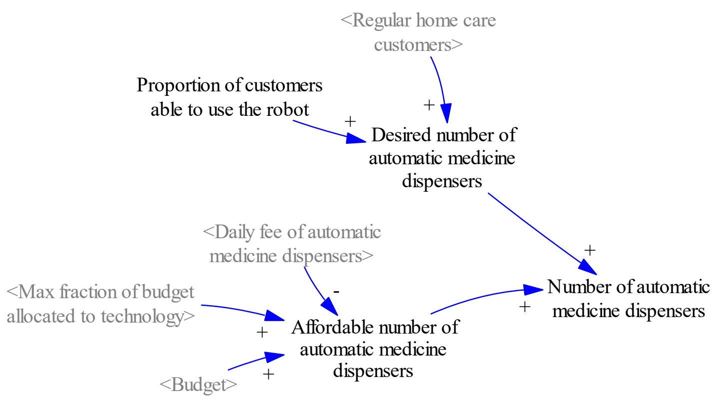

Figure 21: Automatic medicine dispenser robot.

This study considers only the productivity improvements from the technology. The automatic medicine dispenser robot could potentially improve also the health of customers due to improved medicine adherence and decreased errors in medicine delivery. However, these outputs of rational thinking would need to be verified, which is out of the main focus of this study.

4.6 Quality of care

There are two main factors in home care that affects the quality of the service: service delivery delay and corner cutting. The effect of delivery delay is clear because home care service contains many time sensitive caring tasks. If the workload increased too high, postponing the time sensitive tasks would become unavoidable. The effect of delivery delay on quality of care (Figure 22) is not severe if the increase in the delivery delay is small because it is assumed that the home care provider is able to exercise all time sensitive tasks on time by postponing only the less time sensitive tasks. However, as the delivery delay increases it becomes more and more difficult to exercise all time sensitive tasks on time. Furthermore, by postponing the less time sensitive caring tasks long enough, the need for exercising them will become critical in order to maintain the health of customers. For these reasons the effect of delivery delay on quality of care is rapidly decreasing after a slower start.

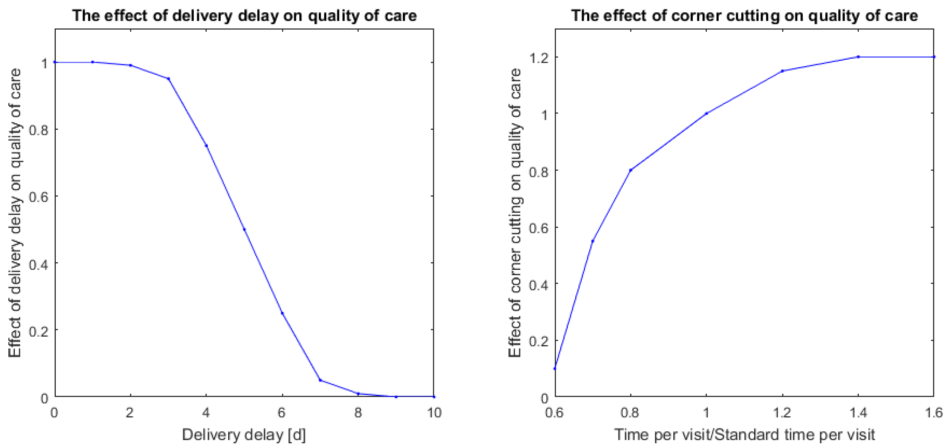

Figure 22: Effects of delivery delay and corner cutting on quality of care.

The corner cutting refers to the increased pace of home visits. As described in Section 4.2, if the work pressure increases, nurses shorten the time they spend at each home visit in order to achieve the target delivery delay. The length of time visits can be shortened by exercising only the most needed caring tasks and acting more quickly. In other words, by cutting corners. Corner cutting is an effective method to meet the target delivery delay in short term but as seen before in Sections 4.2 and 4.3 it increases fatigue and burnout in long term. Furthermore, corner cutting reduces the quality of care. Quality of care decreases rapidly, if the time per visit compared to the standard time per visit decreases. On the other hand, if the time per visit is longer than the standard time per visit, the quality of care increases moderately until it saturates to quality of care 20 per cent higher than on corresponding standard time per visit.

```
Quality of care = Effect of delivery delay on quality of care ·
      Effect of corner cutting on quality of care
```
(48)

```
Effect of delivery delay on quality of care = f(Delivery delay)
```
(49)

```
Effect of corner cutting on quality of care = f(Time per visit/
      Standard time per visit)
```
(50)

The health of customers is assumed to be determined by the quality of care (Figure 23). The effect of service quality on customer health is assumed to follow the dynamics of a first-order system. Discussions with case home care organizations suggest that 75 days is a realistic time after the service quality in home care has an effect on the health of customers.

```
Health of customers = SMOOTH(Quality of care,
      Time after the service quality has an effect on health)
```
(51)

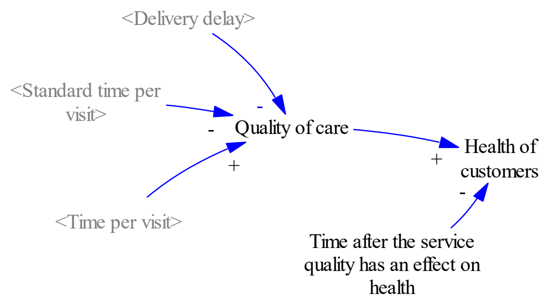

Figure 23: Quality of care and health of customers

The healthier the customers are the less home care visits they need and the longer the home care is an appropriate caring form for them. The effect of customers' health on the required number of home visits was described in the function of needed visits per customer Eq. (11), and on the time as a customer of a home care organization was described in the function of average time in home care Eq. (5).

4.7 Home care budget

The amount of resources available for home care operations depends strictly on the annual budget in public sector. The resources can be modeled as a stock variable that is filled at the beginning of a year[11], and continuously depleted by home care operations that consumes the resources (Figure 24). Currently in Finland, the municipality council grants the resources for the home care organization. Budget policy represents the logic the municipality councils use to grant these resources. The resources in home care are assumed to be allocated with the information of the granted resources. The amount of home care resources available at the beginning of the year is the annual budget. The resources during the year may be positive or negative depending on the budget and the resources used. Therefore, the home care budget at the beginning of a year differs from the granted resources by the previous surplus/deficit. The initial budget is assumed to be 3 million euros, which is the mean value from the last two planned budgets in a home care organization (Appendix B). The resource usage is explained in the following section.

```
Resources = INTEGRAL(Given resources - Used resources,
      Initial budget budget)
```
(52)

```
Given resources = PULSE TRAIN(1, 1, 365, FINAL TIME) ·
      Budget policy
```
(53)

[11] The value of a variable at one specific time can be modeled by utilizing the PULSE TRAIN function.

$y =$ PULSE TRAIN(s, d, r, e) returns a unit impulse starting from the time s, lasting the duration d, repeating the pattern every r time, and ending at the time e. In other words, y is a unit impulse train.

```
Used resources = Home care costs                                        (54)
```

The budget defines the affordable number of employees Eq. (29) and automatic medicine dispenser robots Eq. (46). Because home care is employee intensive field, it is assumed that home care organizations decide the fraction of budget they will spend on technology, equipment and other costs, and the rest is used for the workforce. However, if there is not enough customers that would benefit from the technology and there is a need for a bigger workforce, the spare resources is assumed to be used in recruiting new employees.

```
Employee budget = Budget·(1 - Fraction of budget for other costs)-      (55)
      Technology costs
```

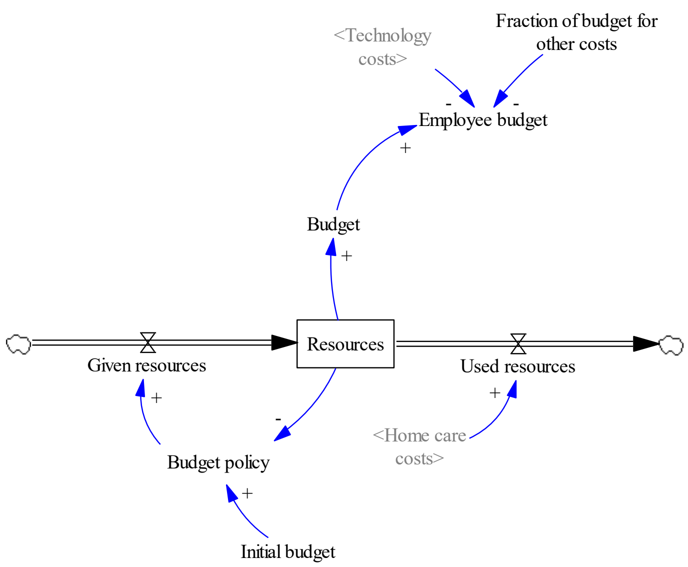

Figure 24: Home care resources

The resources has a negative influence to budget policy in Figure 24 because some budget policies increase the resources if in previous year the resources have been overspent and vice versa. Static budget, constant resources and dynamic budget are the budget policies that are analysed in results section (Section 6). Static budget policy is a simple policy that preserves the granted resources at a constant level, which means that previously given and used resources are irrelevant in decision of granted resources for the home care organization. Constant resources, on the other hand, keeps the available resources at the constant level for every year.

Dynamic budget is set to adapt to the consumption of resources in home care operations. In other words, the granted resources is modified to match with the resource consumption in the previous year. Therefore, the budget policy aims to estimate the needed resources in the home care in order to avoid budget shortages. This type of estimation is also called naïve forecasting.

4.8 Home care expenditures

Home care is an employee intensive field: the output and the operating costs in the home care service are mainly produced by employees. Data from case home care organizations (Appendix B and D) indeed confirm that the employee costs represent a high portion of the overall costs. The proportion of employee costs in the case home care organizations has varied between 69 per cent and 81 per cent. Employee expenditure in home care is determined by the sizes of regular and temporary workforces as well as their estimated costs. An estimated annual cost per regular employee, based on case home care organization's data (Appendix D), is 47 000 euros, which includes all costs of direct service employees plus the costs of supportive employees. It is assumed that the percentage of overhead costs is independent of the direct service resources. In other words, the same proportion of supportive employees are always needed for enabling nurses to perform at the current service level. Temporary employees are assumed to be 15 per cent more expensive than regular employees due to acquiring costs of short term employees.

```
Employee costs in home care = Total workforce·                          (56)
      Estimated cost per employee + Temporary workforce·
      Estimated cost per employee·(1 +
      Estimated overhead of temporary workforce)
```

Technology is another inspected source of expenditures because technological solutions have a potential for increasing the productivity in home care operations. Automatic medicine dispensing service is assumed to have a monthly fee of 150 euros per device. It is the minimum sales cost of the service but it is assumed that the home care organizations will order enough service units to be able to negotiate the lowest price. Initial training, maintenance and technical support are included in the service price, and internal personnel costs of the training are assumed to be negligible. Therefore, technology costs are determined by the number of automatic medicine dispenser robots and the monthly service fee.

```
Technology costs = Number of automatic medicine dispensers·             (57)
      Daily fee of automatic medicine dispensers
```

The expenditures generated by other sources than employees or technology are aggregated to two categories. Firstly, according to data from case home care organizations (Appendix B and D), external services consume approximately 12.5 per cent of home care resources of which 6.7 per cent are spent on other than rental employee services. The costs of rental employee services must be excluded because it is already modeled in the costs of temporary workforce. The second category, material, equipment and other (MEO) costs, are assumed to be dependent on the number of exercised home visits. The two case home care organizations have somewhat similar numbers of home visits and other costs per year, but there is a large difference in the material and equipment costs (Appendix B and D). As a result, the estimated material, equipment and other costs per visit are approximately 7.76 euros and 1.44 euros. Generated costs in home care is the sum of the previously mentioned sources of expenditures. Figure 25 presents the generation of costs in the system under inspection.

```
Home care costs = (Employee costs in home care +
      Home visit completion rate·Estimated MEO cost per visit +
      Technology costs)·1/(1 -
      Proportion of external service costs)
```
(58)

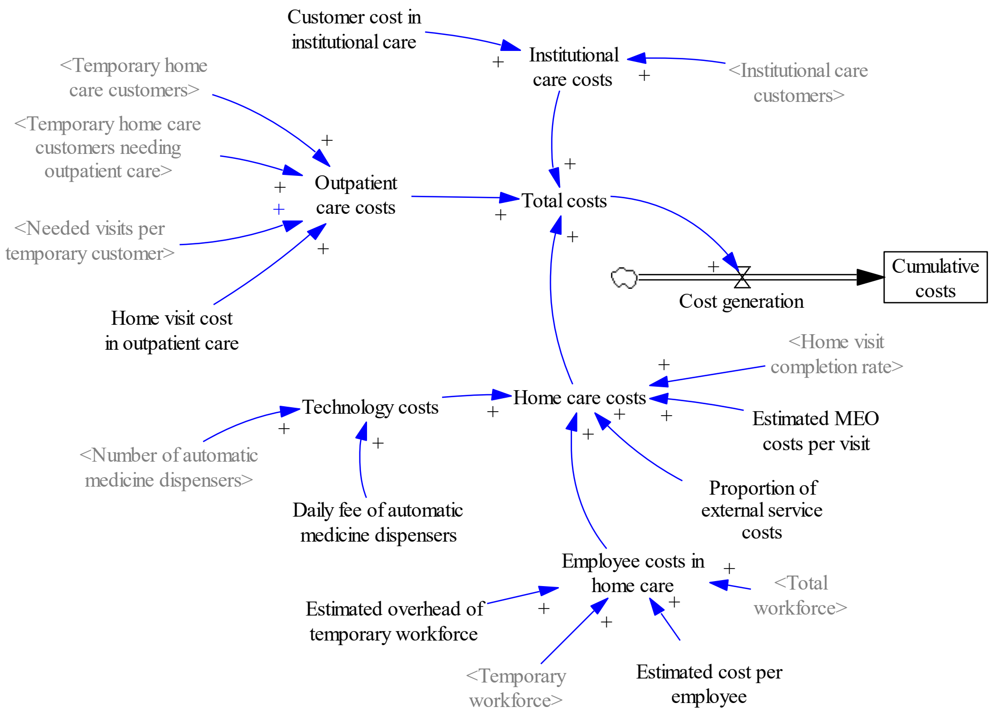

Figure 25: Elderly care expenditures that are under inspection.

Home and institutional care are the types of elderly care services under inspection. In addition, cost of outpatient care related to the eroded service quality in home care is taken into account. The expenditures caused by institutional care are determined by the number of institutional care customers and the daily customer cost in institutional care. Case home care organization's data (Appendix D) show that institutional care costs 130 euros per day per customer. The cost was evaluated as a good estimate also by the interviewees in the other case home care organization. The outpatient care expenditure considered in this study is determined by the temporary customers' home visits that were not able to be exercised by the home care organization multiplied with the outpatient care unit cost. According to Kapiainen et al. [57, p. 27], the recommended home visit unit cost by a nurse in the outpatient care is 110 euros.

```
Institutional care cost = Institutional care customers·
      Customer cost in institutional care
```
(59)

```
Outpatient care costs = Temporary home care customers·
      Temporary home care customers needing outpatient care·
      Needed visits per temporary customer·
      Home visit cost in outpatient care
```
(60)

The sum of home and institutional care costs define the total costs of the system under inspection. Cumulative costs present the accumulation of the total costs over time.

5. TESTING AND VALIDATION

Validation of a model is impossible because models are always simplified and imprecise descriptions of reality. Still, every decision maker uses a mental or formal model to make important decisions. There is not a choice whether to use a model or not but a chance to select the model to use. The responsibility of a decision maker is to use the best model available for the purpose of the decision. [4, p. 850] Testing and validation is therefore an important part of the modeling process because it helps decision makers to evaluate and justify the suitability of the model for the purpose at hand as well as to understand the sensitivity of the outcomes.

Testing and validation started at the same time with the modeling and lasted until the end of this study. Validation of the model relies mainly on the evaluation by the case home care organizations. Three meetings with each case home care organization have been exercised during the study. Moreover, the last meeting was dedicated only for the model validation, comments, suggestions and questions. In other words, case home care organizations have been included rather tightly in the modeling process. The case home care organizations approved the structure and the functioning of the model as representing realistically the real-world system. However, the case technology was not used in one and was implemented rather lately in the other case home care organization, which made it difficult to evaluate the performance of the technology. The assumption of 50 per cent suitability and 50 per cent reduction of needed home visits was evaluated to be an optimistic but possible performance level.

Case home care organizations provided invaluable information and insight in Finnish home care environment. Due to previous experience in the field and insightful initial meetings with the case home care organizations, the structure of the model remained relatively untouchable during the validation process. However, the overtime of employees was removed, temporary employees was added, and the outpatient care replaced the hospital care in the model. Overtime is not commonly used practice in the case home care organizations, temporary employees are used to replace employees on sick leave, and if the home care provider could not take more temporary customers, an outpatient unit would treat the customers instead of an inpatient unit. Furthermore, many functions and values in the model were updated during the validation process. Discussions with the case home care organizations also revealed that their current primary interest is in budgetary aspects. Therefore, the focus of this study was directed to the governance part of responsible management, especially to the budget policies.

Testing augments the validation process to discover errors in the model and to justify the utilization of the model in decision making. Multiple testing methods were used during the modeling process: boundary and structure assessment, dimensional consistency, extreme condition testing, parameter assessment, sensitivity analysis, and behavior tests. More information about these testing methods is provided in Section 3.2. The testing demonstrated clearly the iterative nature of the modeling as it revealed a couple of minor modifications that would improve the validity of the model even at the very late stage of the study.

The aim was to model the effects of the aging society in home care environment and to evaluate the potential of responsible management to tackle the problem. Therefore, model boundaries were set around a home care organization. However, costs generated in institutional care organizations were also taken into account because the service quality of home care providers affects the institutional care costs. Preventive actions before home care service and a possible caring organization after the institutional care service was excluded from the model because these are too far from home care organizations' core operations. Furthermore, home care organizations do not currently have effective tools to affect either preventive elderly care or the care after the institutional care service.

Dimensions of functions and variables are mostly consistent in the model. The formulation of the home care budget causes the only inconsistencies in the dimensions. The dimensional consistency was tested by Vensim ® DSS Version 6.2 tool as well as by mechanically checking the dimensions of equations and variables during the modeling. According to Vensim software, there are two dimensional errors in budget formulation. Both errors in units are caused by the method to formulate the budget for the upcoming year. As described in Section 4.7, the home care budget is assumed to be the amount of resources at the beginning of the year. In order to utilize this method to set the budget for the upcoming year we need to compare the last year's budget (EUR per Year) to the amount of resources (EUR) at the beginning of the year. Therefore, the inconsistencies in the dimensions are results of deliberately made decisions in the model structure, which means that there are not any dimensional problems in the model.

The model produced an expected behavior to most of the extreme condition tests for input parameters. Extreme condition testing was exercised on the following parameters:

- New customers and Net change of temporary home care customers,
- Standard number of visits needed per customer,
- Standard number of visits needed per temporary customer,
- Time to hire, and
- Given resources.

The only irrational behavior occurred when the given resources for the home care was set to an extremely low level. An expected behavior would have been that the operations of the home care unit was shut down quickly. However, the model does not take into account a scenario where employees should be laid off. Furthermore, the model assumes that people in need of care are still firstly served by a home care provider. Thus, removing the resources from the home care provider decreases the number of employees due to a natural attrition as resources do not allow hiring new employees to compensate the ones who leave. The shortage of care employees wrecks the service quality in home care, which eventually decreases customers' health and makes them to move to institutional care. Instead of the expected quick closure, the extremely low level of resources shuts the home care operations down rather slowly. A scenario that contains laying off home care employees is not a relevant scenario in this study due to the increasing workload in home care. However, if the user of the model would like to test decision making politics where laying off employees is a potential scenario, then one should add the corresponding functioning to the model.

Parameter assessment was a part of the validation process exercised with the case home care organizations. Home care managers have the best knowledge about the operations of their organizations, and at least a good understanding of the operational environment of Finnish home care providers. The parameter assessment was still enhanced by sensitivity analysis. Sensitivity analysis was exercised by the Vensim software on every constant variable in the model. Sensitivity of a variable was tested by 500 Monte Carlo simulations. The value of the variable under analysis was set to follow a uniformly distributed random variable. The minimum and the maximum values of the random variable was set to 30 per cent lower and higher than the value in the model. Sensitivities of constant variables were tested under static and dynamic budget policies, and the evaluation was exercised by inspecting five system variables:

- Regular home care customers,
- Work pressure,
- Effective workforce,
- Health of customers and
- Cumulative costs.

Sensitivity analysis revealed that the system is remarkably more sensitive under the static budget policy compared to the dynamic budget policy. In control theory terms, the static budget policy is an open loop control of resources. Therefore, in this case the system lacks a balancing element that could control the output. The dynamic budget policy, on the other hand, is a closed loop control of resources, which enables adjusting the resources better to meet the operational needs. Despite the selected budget policy, the model behavior was rather sensitive to the variables closely related to work pressure in home care compared to other variables. Therefore, assumptions related to the amount of work or the service capacity should be carefully considered. However, the analysis shows that the system is quite insensitive to delay times even when they were related to the amounts of regular customers and workforce. Moreover, the system is relatively insensitive to the number of temporary customers, even though it affects directly the amount of work. The reason for this insensitivity is that the temporary customers represent only approximately 13 per cent of the total customers. For this reason, a perturbation in the number of temporary customers will have a dampened response to the output of the whole system. Because the system is rather insensitive to the changes in the number of temporary customers, the decision to discard the data from the year of 2015 in Section 4.1 does not have a dramatic impact on the results. Figures 26-28 present an example of Monte Carlo simulation of one rather sensitive constant in the model, Standard visits per day.

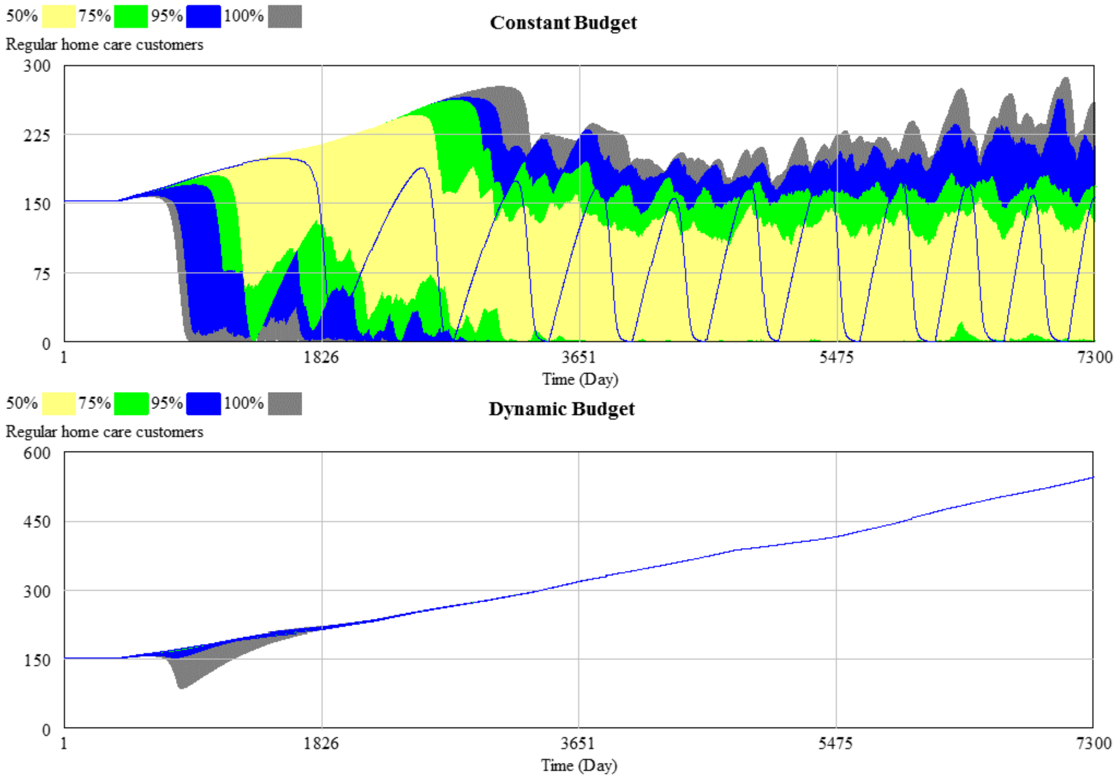

Figure 26: Sensitivity analysis of Standard visits per day. The variation of Regular home care customers under constant and dynamic budget policies. The model is set to remain in balance for the first year.

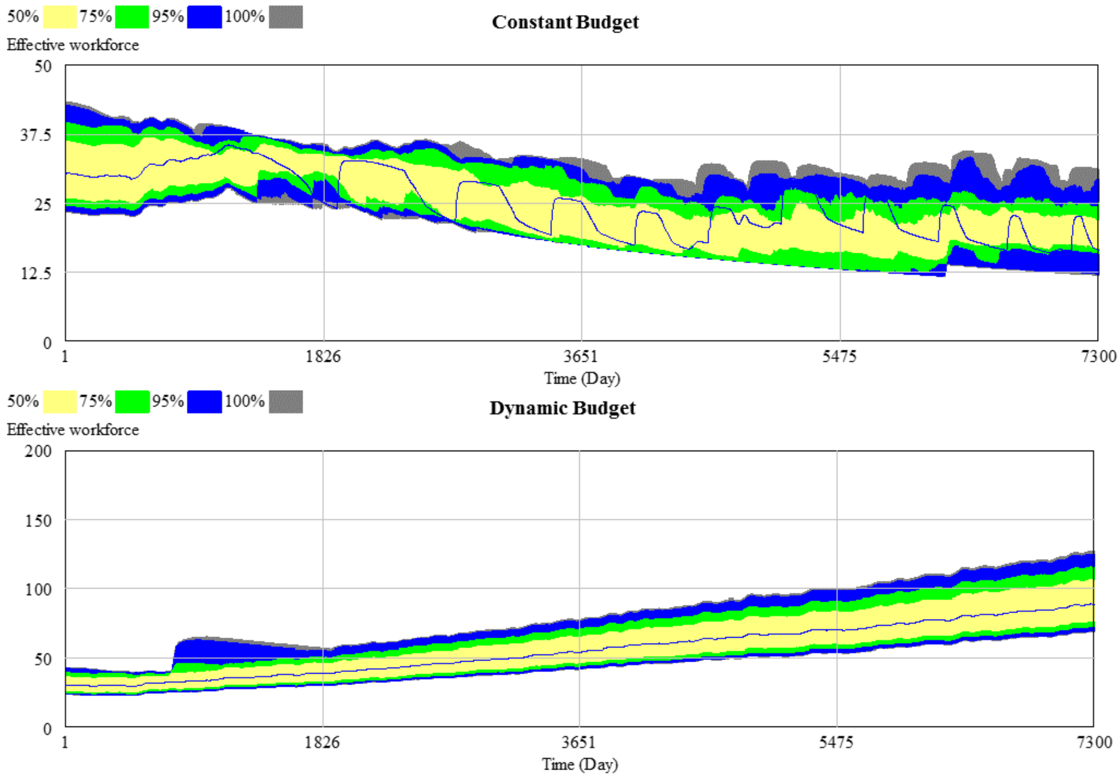

Figure 27: Sensitivity analysis of Standard visits per day. The variation of Effective workforce under constant and dynamic budget policies.

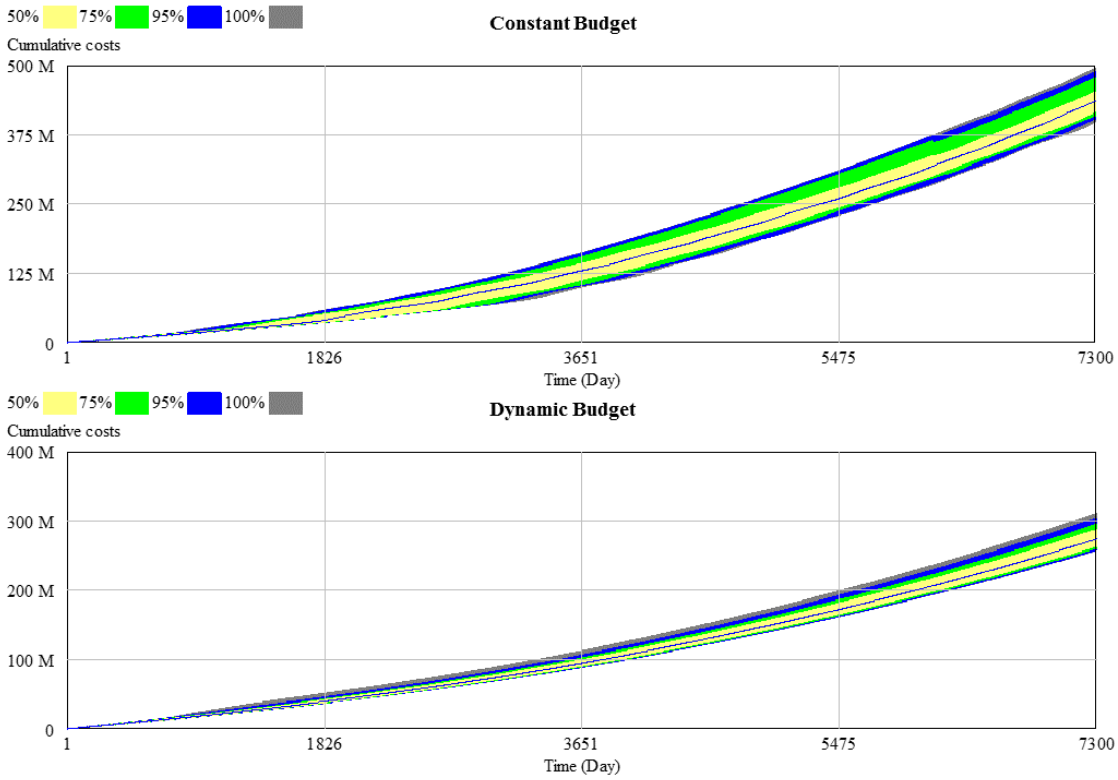

Figure 28: Sensitivity analysis of Standard visits per day. The variation of Cumulative costs under constant and dynamic budget policies.

Figure 26 shows that under the constant budget policy the number of regular home care customers is sensitive to the value of standard visits per day. In the worst scenario, the number of regular customer collapses after a couple years of simulation. In the best scenario, on the other hand, the home care provider is able to operate almost ten years with the same budget policy before the collapse of regular customers. Under the dynamic budget policy the home care provider is able to provide caring services to every potential customer. In the worst 5 per cent of simulations, however, the number of regular home care customers drop at the beginning of simulation but the budget policy enables adjusting the operations in the right direction to set the process back to the track. The problem is tackled by recruiting new employees as shown in Figure 27. Because the standard visits per day is representing the effectiveness of home care employees, the size of effective workforce is quite sensitive to this variable even if the static budget would constraint the authorized workforce. Despite the strict budget control, the cumulative total costs varies more under the static budget policy compared to the dynamic budget policy. Corresponding graphs for work pressure and quality of care were not presented because the number of regular customers illustrates the sensitivity most clearly. The effect is similar in the work pressure and quality of care variables because the number of regular customers affects the work pressure that affects the quality of care that again affects the number of regular customers.

Under the constant budget policy the model clearly produces the foreseen future behavior. The dynamic hypothesis assumed that aging society will increase the workload in home care that will eventually erode the service quality, which will cause relatively high expenditures in elderly care. The model also produces closely the same cost for a home care visit as the suggestion by Kapiainen et al. [57, p. 42]. In the initial equilibrium, the model produces approximately 40 or 42 euros cost per home visit depending the selected technology policy, and Kapiainen et al. suggest to use 42 euros as a cost of a home care visit in Finland. This result indicates that the model is able to produce quite accurately the correct costs of the operations. Behavioral testing cannot, however, evaluate the accuracy of the model to produce the correct operational behavior due to future oriented perspective and lack of data.

6. RESULTS

The thesis aimed to enhance understanding of the upcoming challenges caused by the aging society and to evaluate the potential of responsible management as a solution. The case home care organizations were merely interested in the governance in responsible management, and maintaining customers' quality of life by exercising caring activities is the ultimate goal of home care services. For these reasons, potential managing policies are evaluated by inspecting their effects on the health of customers and on the cumulative costs in elderly care. Thus, the aim of this study is to find policies that would keep the system on the current state or drive the system to a state where either the service level is improved or the costs are reduced. However, due to a high expected growth of number of customers it is very unlikely to find policies that at current quality of care would reduce the absolute costs of the public elderly care from the initial level. Thus, the evaluation should consider the relative outcomes of optional policies.

The first subsection describes the structural analysis of the model. The second subsection gives a deeper understanding of the system as a result of simulation analysis. The third subsection presents recommended policies to manage the challenging situation and to avoid vicious cycles.

6.1 Structural analysis

A structural analysis focuses on inspecting the relationships of the system elements that have a great effect on the system behavior. Therefore, feedback structures are under the inspection in the structural analysis. Balancing feedback loops try to keep the system in the equilibrium whereas self-reinforcing feedback loops drive the system to the ongoing direction. The structural analysis of the model revealed that the dynamics of the home care operations is mainly a combination of three balancing and four self-reinforcing feedback loops (Table 4). The dominance of the feedback loops will determine their relative strength to the dynamic behavior of the overall system that is the sum of the subsystem dynamics.

Table 4: Important feedback loops in the home care system. The explanations describe the effect of the perturbation in the system ceteris paribus.

Balancing feedback loops	
Descriptive name	**Explanation**
Corner cutting	If service backlog increases, the work pressure in the home care organization increases. Increased work pressure leads to corner cutting that allows shorter time per visit. Shortened time per visit increases the exercised home visits per nurse, which increases the output of the home care provider and decreases the service backlog.
Place to recover	If the quality of care is eroded in the home care services, an increased fraction of temporary customers need outpatient care services to recover. This reduces the number of temporary customers in home care services, which decreases the work pressure. Decreased work pressure will allow more time for each home visit, which improves the service quality.
Time to move	If the number of regular home care customers increases, more home visits need to be exercised daily, which increases the work pressure in the home care organization. Increased work pressure leads to a corner cutting that reduces the service quality. Reduced service quality will eventually decrease the health of customers, which makes home care customers to require more intensive caring forms sooner. In other words, the number of regular home care customers decrease due to shortened average time the customers can utilize home care services.
Self-reinforcing feedback loops	
Descriptive name	**Explanation**
Fatigue	If the level of fatigue increases among the employees, the service capacity will decrease due to reduced productivity. The decreased service capacity will increase the work pressure that will lead to still greater fatigue among the employees.
Burnout	If the level of burnout increases, more employees need sick leaves to recover from the long-term strain. Increased number of sick leaves reduces the service capacity, which increases the work pressure that will lead to still increased level of burnout.

Hurry	If there is less time to exercise each home visit, nurses are not able to fully focus on required tasks, which expose them to work-related accidents. Accidents lead to sick leaves that reduce the service capacity that will still reduce the time available per home visit.
Frails need care	If the health of customers decreases, home care customers will need more home visits each day, which will increase the service backlog. Increased service backlog leads to higher work pressure that will lead to lowered service quality. Eventually the health of customers will decrease to still lower level.

The analysis of the feedback loops presented in Table 4 suggests that the work pressure is a critical variable in the system because it is involved in every feedback loop. In order to keep the system at the current state, balancing feedback loops must be the dominant behavior. On the other hand, to drive the system to a better state, the system must be set to the desired path. Furthermore, the impact of the control actions needs to be sufficient to change the dominance of the system behavior on the desired self-reinforcing feedback loops. According to the structural analysis of the model, if the work pressure is under control, balancing feedbacks are dominating and perturbations will only cause minor distractions to the output. Therefore, the question is: how to keep the work pressure under control if the number of customers increases due to the aging society? In order to drive the system to a better state, actions that have even more positive impact on the work pressure must be found.

The structural analysis suggests that either the needed visits per customer should be decreased or the service capacity should be increased in order to match the service capacity with the workload. The analysis also proposes that adequate resources should be allocated to home care services to avoid vicious cycles. If the system drifted to a vicious cycle, the home care provider would produce a low output with high costs. However, the situation is problematic, because the service quality cannot decrease and the current budget policy strongly constraints the selection of potential solutions.

6.2 Simulation analysis

An analysis of the simulation model is started by simulating the base case that describes the standard policy in many home care organizations. The base case contains a static budget policy as well as a policy not to use the case technology in home care operations. The simulation of the base case reveals that this policy is not sustainable in long term. When the number of customers increases, the base case policies lead to a vicious cycle. In the base case, the home care provider is not able to match the service capacity with the demanded home visits, which leads to high work pressure, eroded service quality, lower health of customers and lower productivity in home care organization. As a result, the emphasis of elderly care shifts from home care to institutional care, which increases the total costs of elderly care. However, after the vicious cycle has moved the state of the system enough, balancing feedback loops become dominant and the system will return close to the initial state until the vicious behavior takes control of the system again. In other words, the base case policies generate oscillation in the system. Furthermore, the highest health during a cycle is decreasing in time.

The collapse of the service quality and the health of customers after a few simulation years is an alarming result. If home care organizations in Finland are using similar policies, this phenomenon is expected to happen in the near future. Furthermore, badly functioning operations in home care increase greatly the overall costs of the elderly care. A big challenge, however, is that even though the system oscillates wildly, the costs in home care services are relatively stable. The management system therefore lacks an effective feedback, if the home care manager and the supervising board use costs as the key performance indicator. Actually, the simulation results show that the average home care costs even slightly decrease during the simulation but at the expense of high increase in institutional care costs.

In order to improve the understanding of the effects of optional policies, three budget policies and two technology policies were tested during the simulation analysis. Tested budget policies were static budget, constant resources and dynamic budget. No technology resources and maximum 15 per cent of budget to technology were the tested technology policies. The results show that any other combination of budget and technology policies beats the base case in comparison of the cumulative elderly care costs. However, only the dynamic budget policy allows the home care organization to response sufficiently to the increased workload. Simulation results are presented in Appendix E. Figures 29-31 present the effects of tested policies on regular home care customers, cumulative elderly care costs and the health of home care customers respectively.

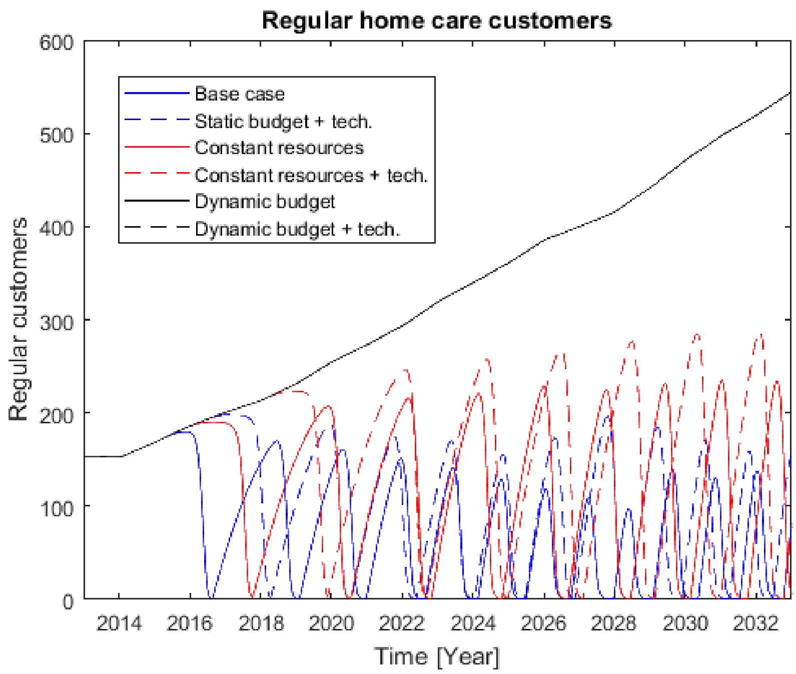

Figure 29: Simulation results for the regular home care customers under tested budget and technology policies

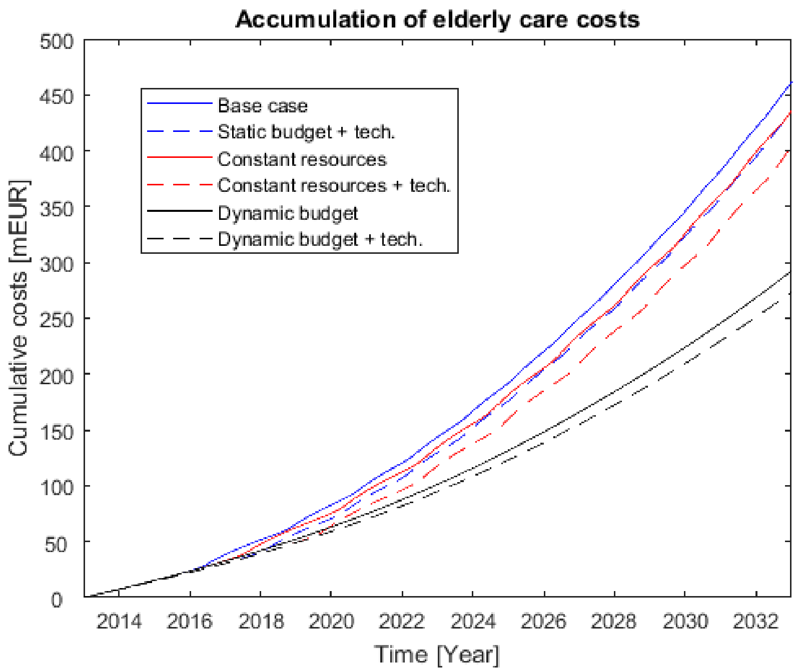

Figure 30: Simulation results for the accumulation of elderly care costs under tested budget and technology policies

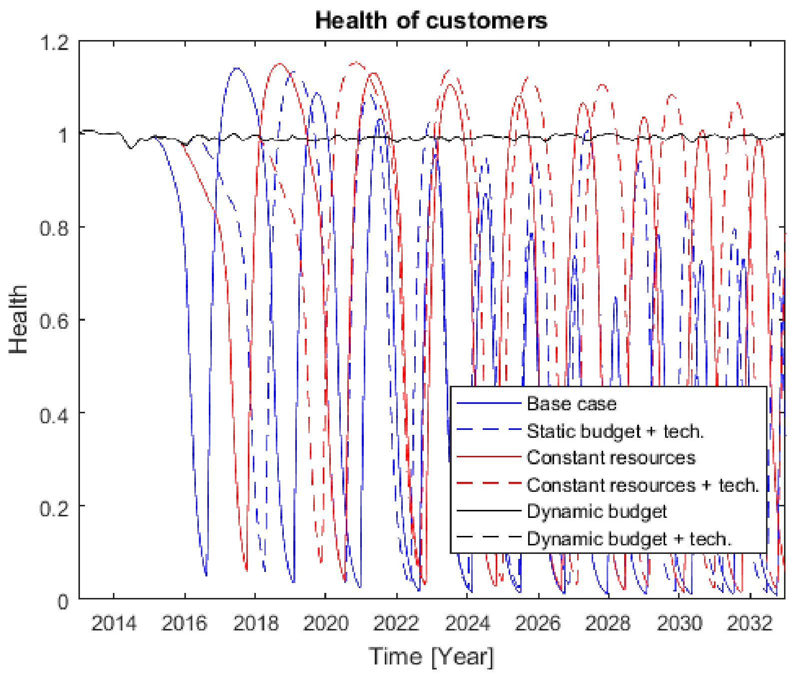

Figure 31: Simulation results for the health of customers under tested budget and technology policies. Health is a dimensionless variable.

The static budget policy led the system to a vicious cycle as described above. The utilization of the technology delays the inevitable by less than 1.5 years. The constant resources budget policy lead only to a slightly better result compared to the static budget policy. Still, constant resources policy with the utilization of technology is able to delay the collapse of the service quality in home care by more than three years compared to the base case. Even though the constant resources policy will eventually lead to the oscillation, together with the favorable technology policy it may be a key to solve the problem of the aging society. The ability to delay the vicious cycle for three years may allow public government enough time to decide on a better and permanent solution for the problem. Three years extension may also allow technology developers to discover innovations that would help policy makers to solve the problem.

Dynamic budget policy adapts to the resource consumption and tries to predict the resource need for the upcoming year by naïve forecasting. According to simulation results, this method is effective to provide the adequate amount of resources for home care organizations to meet their obligations. If the home care organization needed additional resources in a particular year, the next year's budget would be adjusted to the observed higher resource consumption. Therefore, dynamic budget policy allows the home care provider to adapt their operations to the changes in the operational environment. The simulation shows that the dynamic budget policy produces good results regardless the decided technology policy.

6.3 Policy design

Structural and simulation analyses propose that the governance of elderly care should allow sufficient resources for home care providers to enable high quality and cost effective elderly care. Removing the budget constraint from home care providers would be the most convenient method to ensure the adequate resources. Dynamic budget policy is close to the no budget constraints policy as the dynamic budget is always adjusted to the observed resource consumption. These policies, however, are not realistic options because they may encourage home care providers to a careless resource usage. On the other hand, simulation analysis revealed that strict budget constraints are not enabling home care organizations to meet their obligations in long run, which will lead to decreased quality of care as well as to higher total costs of the elderly care. Therefore, the budget policy of home care providers should be at the same time elastic and strict. An elastic budget policy enables adaptation to the changes in operational environment; and a strict budget policy prevents overspent of resources, which enables adequate resource allocation also to other functions of public governance. For these reasons, the home care budget should be adjusted according to the changes in the key indicators from the operational environment. The trends of number of customers and their health are examples of the potential key indicators that are already measured in public home care organizations in Finland. If the budget is formed according to the key indicators, the policy does not allow increased costs due to bad decisions but enables the home care provider to meet its obligations.

If the public finance lacks resources, the compensating actions should be considered carefully. If the resource shortages resulted to budget cuts in home care, there is a risk that the home care organization ends up in a vicious cycle that will erode the quality of care. As a result, the elderly care costs will rise and even more financial difficulties will be expected in the future. Therefore, it would be responsible to evaluate both short and long term effects of policies. For example, loaning resources from financial market instead of cutting costs in home care, could be financially better choice in long run. Public home care providers could also increase the customer payments or force the most wealthy customer segments to private services. Moreover, the public finance could be improved by reducing the effect of the aging society on the dependency ratio by lengthening the working careers of people.

An effective utilization of technology appears to be a key to the cost efficient organization of the elderly care services. Even though the performance of the technology cannot be precisely confirmed beforehand, the potential is huge. If the technology costs 1800 euros per year and an employee generate 47 000 euros annual expenditure, the case technology would be financially superior even if it could only reduce 4 per cent of home visits from suitable customers. Therefore, the actual proportion of reduced visits could be even a tenth of the assumed and the technology would still be justified. This result indicates that from financial perspective the technology should be utilized as much as possible. However, the downsides of the technology should be kept in mind when the decisions of technology utilization is made. For example, interoperability with other functions, reliability, and the possible side effects on service quality and loneliness should be evaluated.

The utilization of technology may actually be the only option to maintain the current service level of elderly care in the future. The model predicts that the number of elderly care customers will be almost 3.5 times higher in 2034 than it was in 2014. Furthermore, the dependency ratio will grow in the society. These upcoming changes in the society may lead to a situation where not adequate number of elderly care personnel is available at the market. Therefore, either the productivity of employees must rise or the workload per employee must be reduced. Improving the productivity or reducing the workload is difficult without technological innovations. Therefore, to avoid this challenging situation, readiness for technology utilization in home care operations should rather be started sooner than later.

Another method to improve the cost efficiency in the home care operations would require a possibility for home care providers to recruit an internal reserve of employees. Currently the workforce on sick leave is compensated by temporary employees. However, temporary employees are more expensive and less effective than experienced employees. According to the model, exercising the demanded home visits by temporary workforce is 40 per cent more expensive than exercising the corresponding workload by experienced employees. If on average 10 per cent of employees were on a sick leave, which is the current situation in the case home care organization, the home care provider could potentially save approximately 4 per cent in employee expenses by recruiting internal employee reserve. The positive effect of internal employee reserve is emphasized as the size of the home care unit increases. According to the law of large numbers, the variation of the number of employees on sick leave will be relatively lower in large units, which allows relatively smaller employee reserve to manage the variation in the effective workforce.

7. CONCLUSIONS

Finnish healthcare will confront major challenges due to the aging of society. The challenges will affect especially public home care providers as the emphasis of the Finnish elderly care is focused on the home care. The change in the operational environment is predicted to be drastic. When the society ages, the dependency ratio changes to unfavorable direction for public elderly care providers. As a result, the workload in the home care services will increase, the availability of skillful workforce will not keep up with the pace of the increase in the service demand, and there are fewer people to support public services. Furthermore, the financial crisis in 2008 caused a sustainability gap in the Finnish government finance, which has resulted to a political decision to decrease the expenditure in healthcare. Therefore, the public home care providers will meet a contradictory challenge to serve more customers with less resources. The challenge requires home care providers and policy makers to discover novel methods to maintain the service level of public elderly care. This thesis conducted a systemic research that evaluated the potential of responsible management as a solution.

The dynamic hypothesis assumed that firstly, the aging society will increase the workload and secondly, the financial restrictions do not allow recruiting adequate number of employees. High work pressure will eventually erode the service quality in home care, which redirects the emphasis of the elderly care to relatively expensive reactive caring services. The simulation model was formalized to evaluate the dynamic hypotheses and to augment the understanding of the system. The sensitivity analysis of the model revealed that the system is remarkably more sensitive under the strict budget restrictions than if the budget allows the organization to adapt the operations according to the changes in the operational environment.

The structural analysis of the model discovered that the dynamics of the system mainly results from the interaction of three balancing and four self-reinforcing feedback loops. Which of the feedback loops are dominant determines the system behavior. If the balancing feedback loops dominate, the system will balance the perturbations and the state will return to the equilibrium, whereas the dominance of the self-reinforcing feedbacks generates either virtuous or vicious cycles. The structural analysis confirms that the work pressure is indeed an important variable in the system. If the work pressure stays below a critical threshold, balancing feedbacks are dominant in the system and perturbations will only cause minor and temporary distractions. According to the structural analysis, if the number of customers increase, either the exercised visits per customer should be decreased or the service capacity should be increased in order to keep the work pressure below the critical threshold. However, the latter is the only option if the current service quality would like to be maintained. The analysis also proposes that home care providers should have adequate resources to avoid vicious cycles. If the system ended up in a vicious cycle, the elderly care system would produce poor quality and high costs.

The simulation analysis evaluated the outcomes of three budget policies and two technology policies. The static budget policy assumed that the home care provider receives a constant amount of resources for each year. If the budget was exceeded under the static budget policy, the lacked resources would be taken from the next year's budget. The constant resources policy ensures a constant budget for each year. The dynamic budget policy utilizes naïve forecasting to predict the resource consumption for the next year and adjusts the budget according to the prediction. The alternative technology policies tested were: no technology, or at most 15 per cent of the budget spent in technology. According to the simulation analysis, the selected budget policy had a stronger impact on the system outcomes than the selected technology policy. The analysis also revealed that the dynamic budget was the only budget policy that allowed the home care provider adequate resources to manage the increased workload. Both static budget and constant resources policies were not able to prevent the system from drifting to a vicious cycle.

Policy recommendations were designed according to the findings from the structural and simulation analyses. The case home care organizations were mostly interested in the governance part of the responsible management; and maintaining customers' quality of life is the ultimate goal of the home care services. The policy design was therefore directed to support decision making related to these subjects. The policy design suggested that the budget policy should take into account the changes of key indicators in the operational environment. This policy would allow sufficient resources for the home care provider but prevents overspending due to a careless management. The trends of customers and their health are potential key indicators. If the public finance does not allow enough resources for the elderly care, the cutting of home care costs should be carefully considered. If the home care ended up in a vicious cycle, even larger financial difficulties for the elderly care will be expected in the future. Therefore, it would be irresponsible to overrate short-term benefits or to fall in temptation of the managerial myopia: favoring short-term profits over the long-term gains.

The policy design also proposed that technological applications should be included in the home care operations. The evaluated case technology could be financially justified even if the performance was only one tenth of the expected based on prestudies. Furthermore, technological applications may be the only way to manage the upcoming workload challenge due to the predicted, significant increase in the number of customers. Another discovered method to improve the cost efficiency in a home care organization could be achieved by recruiting an internal employee reserve. According to the model assumptions, temporary employees generate 40 per cent more expenditure than experienced employees to exercise the equivalent amount of work. Therefore, the internal employee reserve has a potential to substantial savings as well as to improve the home care processes.

The elderly care services is a complex system in a complicated situation. This thesis visualized the functioning of the home care system, enhanced the understanding about the dynamics in the elderly care and provided policy recommendations to response to the predicted challenges in the operational environment. An interesting field of the future research would be to innovate actions preventing the increase in workload and to evaluate their potential. The future research could also deepen the understanding of the effects of the responsible management in home care operations. A lower abstraction level study of the functions of a home care provider would complement the results of this thesis. Moreover, future studies could utilize the model developed in this thesis in order to find an optimal dynamic budget policy for public home care providers. The optimality of the budget policy should consider the trade-off between costs and service quality, and a holistic evaluation of consequences in different time scales.

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APPENDIX A: HOME CARE AND POPULATION DATA

The used home care and population data can be obtained from the THL's Sotkanet service. The data was collected from all Finnish municipalities as well as from the whole Finland on the following variables:

- Population aged 65-74 as % of total population
- Population aged 75-84 as % of total population
- Population aged 85 and over as % of total population
- Population at year end
- Regular home care, clients on 30 Nov
- Residential homes for older people, clients on 31 Dec
- Service housing with 24-hour assistance for older people, clients on 31 Dec

The sum of residential homes for older people and service housing with 24-hour assistance for older people is the number of institutional care customers. Data was saved from 2001 to 2016. However, the years that did not contain data in all variables were removed. A link to the data:

https://www.sotkanet.fi/sotkanet/en/taulukko?indicator=szZyt041ttY1S7QuC7DWLYgPtdZ1DQYA&region=VVBbCgMx-CLxRQMewLJ6jP_0JpbT3P0LVybaWgJqZ8ek6dImp65CI8Gc6P8Kao-Iidnx-Efj8aQRuQwLX9MtkK8VkiuYrHHQhL_Bq2juI_fXTVlUzBOICF4i3KkaiJe2y9FY4OM-pRW9BSGhsFGem5UCr7eO-0c88FHsvaOWhJ72MscGRcX4rO2t_xcnmse93x9gE=&year=sy4rt7bU0zW0NtbTN-QIA&gender=t

APPENDIX B: CASE HOME CARE ORGANIZATION 1 DATA

STATEMENT OF EARNINGS:

	2015					
	Original budget	Budget changes	Budget after changes	Realization 1-12/2015	Deviation	Tot-%
Return						
Sales return	**747 763**	**0**	**747 763**	**719 907**	**27 856**	**96,3**
Military injury indemnity	39 000	0	39 000	3 061	35 939	7,8
Other cooperation returns	702 063	0	702 063	711 876	-9 813	101,4
Apprenticeship education	3 800	0	3 800	4 000	-200	105,3
Other sales return	2 900	0	2 900	970	1 930	33,4
Payments	**257 000**	**70 000**	**327 000**	**390 952**	**-63 952**	**119,6**
Other healthcare payments	0	0	0	11 275	-11 275	
Other domestic aid payments	257 000	70 000	327 000	379 677	-52 677	116,1
Other social service payments						
Subsidies	**16 900**	**0**	**16 900**	**11 611**	**5 289**	**68,7**
Employment subsidy	16 900	0	16 900	11 611	5 289	68,7
Other returns						
Rented accommodation						
Other returns						
Total returns	**1 021 663**	**70 000**	**1 091 663**	**1 122 470**	**-30 807**	**102,8**
Costs						

Personnel costs	**-2 365 395**	**0**	**-2 365 395**	**-2 198 809**	**-166 586**	**93,0**
Salaries and bonuses	**-1 844 327**	**0**	**-1 844 327**	**-1 728 055**	**-116 272**	**93,7**
Monthly salaries	-1 613 714	0	-1 613 714	-1 531 714	-82 000	94,9
Temporary employee salaries	-97 802	0	-97 802	-55 364	-42 438	56,6
Prime costs	-170 000	0	-170 000	-175 459	5 459	103,2
Temps during education	-3 000	0	-3 000	0	-3 000	0,0
Other salaries	0	0	0	-200	200	
Periodic salaries and bonuses	-18 311	0	-18 311	-18 703	392	102,1
Health insurance compensation	57 000	0	57 000	35 854	21 146	62,9
Accident indemnity	1 000	0	1 000	17 433	-16 433	1 743,3
Other KELA compensations	500	0	500	98	402	19,6
Indirect personnel costs	**-521 068**	**0**	**-521 068**	**-470 754**	**-50 314**	**90,3**
Retirement costs	**-404 403**	**0**	**-404 403**	**-361 058**	**-43 345**	**89,3**
KuEL-salary based payments	-376 903	0	-376 903	-303 200	-73 703	80,4
KuEL-pension based payments	0	0	0	-52 888	52 888	
KuEL-primitive payments	-27 500	0	-27 500	-4 970	-22 530	18,1
Other indirect personnel costs	**-116 665**	**0**	**-116 665**	**-109 696**	**-6 969**	**94,0**
National pension and health insurance payments	-41 459	0	-41 459	-35 570	-5 889	85,8
Unemployment insurance contribution	-58 420	0	-58 420	-53 695	-4 725	91,9
Accident insurance payment	-6 595	0	-6 595	-13 229	6 634	200,6
Other social insurance payments	0	0	0	-1 058	1 058	
Periodic social insurance payments	-10 191	0	-10 191	-6 144	-4 047	60,3
Service purchases	**-151 331**	**0**	**-151 331**	**-387 492**	**236 161**	**256,1**

Office and expert services	-600	0	-600	-27	-573	4,5
ICT services	-51 300	0	-51 300	-113 282	61 982	220,8
Employee renting	0	0	0	-160 103	160 103	
Printing, announcements and advertisements	-750	0	-750	-968	218	129,1
Postal services	-7 100	0	-7 100	-1 711	-5 389	24,1
Insurances	-900	0	-900	-1 182	282	131,3
Sanitation and laundry services	-20 981	0	-20 981	-24 554	3 573	117,0
Construction and maintenance services	-300	0	-300	0	-300	0,0
Machinery services	-500	0	-500	-511	11	102,2
Accommodation and nutrition services	-550	0	-550	-536	-14	97,5
Employee education, accom-modation and nutrition	-600	0	-600	-385	-215	64,2
Traveling and transportation	-56 000	0	-56 000	-63 451	7 451	113,3
Employee education, traveling and transportation	-1 000	0	-1 000	-1 212	212	121,2
Social and health services	0	0	0	-13 780	13 780	
Education and cultural services	0	0	0	-581	581	
Employee education and course fees	-10 250	0	-10 250	-3 604	-6 646	35,2
Other cooperation shares						
Other services	-500	0	-500	-1 605	1 105	321,0
Materials and equipment	**-111 400**	**-120 000**	**-231 400**	**-312 971**	**81 571**	**135,3**
Office supplies	-700	0	-700	-1 366	666	195,1
Literature	-500	0	-500	-144	-356	28,8
Groceries	-200	0	-200	-26	-174	13,0
Clothes	-500	0	-500	0	-500	0,0
Drugs	-900	0	-900	-326	-574	36,2

Caring equipment	-98 500	-120 000	-218 500	-303 637	85 137	139,0
Cleaning material and equipment	-800	0	-800	-326	-474	40,8
Fuel	-6 800	0	-6 800	-4 808	-1 992	70,7
Vehicles	-1 500	0	-1 500	-1 247	-253	83,1
Other materials and equipment	-1 000	0	-1 000	-1 091	91	109,1
Other costs	**-58 600**	**0**	**-58 600**	**-69 296**	**10 696**	**118,3**
Rents of buildings	-44 660	0	-44 660	-53 758	9 098	120,4
Leasing costs	-13 500	0	-13 500	-14 361	861	106,4
Other rents	-240	0	-240	-207	-33	86,3
Indirect taxes	0	0	0	-210	210	
Direct taxes	-200	0	-200	0	-200	0,0
Other costs	0	0	0	-20	20	
Credit lost	0	0	0	-740	740	
Total costs	**-2 686 726**	**-120 000**	**-2 806 726**	**-2 968 568**	**161 842**	**105,8**
Marginal profit	**-1 665 063**	**-50 000**	**-1 715 063**	**-1 846 098**	**131 035**	**107,6**
Write-offs						
Write-offs	**-44 100**	**0**	**-44 100**	**-19 357**	**-24 743**	**43,9**
Write-offs from computer programs	-34 000	0	-34 000	-16 010	-17 990	47,1
Write-offs from machinery	-10 100	0	-10 100	-3 347	-6 753	33,1
Total write-offs	**-44 100**	**0**	**-44 100**	**-19 357**	**-24 743**	**43,9**
Profit	**-1 709 163**	**-50 000**	**-1 759 163**	**-1 865 455**	**106 292**	**106,0**

Surplus/deficit	**-1 709 163**	**-50 000**	**-1 759 163**	**-1 865 455**	**106 292**	**106,0**

	2016					
	Original budget	Budget changes	Budget after changes	Realization 1-12/2016	Deviation	Tot-%
Return						
Sales return	**704 064**	**23 000**	**727 064**	**795 321**	**-68 257**	**109,4**
Military injury indemnity	0	0	0	1 669	-1 669	
Other cooperation returns	702 064	23 000	725 064	792 195	-67 131	109,3
Apprenticeship education	400	0	400	1 000	-600	250,0
Other sales return	1 600	0	1 600	457	1 143	28,6
Payments	**458 300**	**15 000**	**473 300**	**440 761**	**32 539**	**93,1**
Other healthcare payments	0	0	0	140	-140	
Other domestic aid payments	0	0	0	40 921	-40 921	
Other social service payments	458 300	15 000	473 300	399 700	73 600	84,4
Subsidies	**6 300**	**0**	**6 300**	**1 373**	**4 927**	**21,8**
Employment subsidy	6 300	0	6 300	1 373	4 927	21,8
Other returns	**0**	**0**	**0**	**1 680**	**-1 680**	
Rented accommodation	0	0	0	684	-684	
Other returns	0	0	0	996	-996	
Total returns	**1 168 664**	**38 000**	**1 206 664**	**1 239 135**	**-32 471**	**102,7**

Costs						
Personnel costs	**-2 316 509**	**-18 000**	**-2 334 509**	**-2 321 729**	**-12 780**	**99,5**
Salaries and bonuses	**-1 819 092**	**-18 000**	**-1 837 092**	**-1 810 895**	**-26 197**	**98,6**
Monthly salaries	-1 664 508	0	-1 664 508	-1 642 542	-21 966	98,7
Temporary employee salaries	-22 063	-18 000	-40 063	-52 557	12 494	131,2
Prime costs	-161 000	0	-161 000	-184 904	23 904	114,8
Temps during education						
Other salaries	0	0	0	-90	90	
Periodic salaries and bonuses	-18 521	0	-18 521	5 181	-23 702	-28,0
Health insurance compensation	46 500	0	46 500	58 395	-11 895	125,6
Accident indemnity	0	0	0	3 392	-3 392	
Other KELA compensations	500	0	500	2 230	-1 730	446,0
Indirect personnel costs	**-497 417**	**0**	**-497 417**	**-510 834**	**13 417**	**102,7**
Retirement costs	**-373 606**	**0**	**-373 606**	**-396 287**	**22 681**	**106,1**
KuEL-salary based payments	-372 285	0	-372 285	-321 811	-50 474	86,4
KuEL-pension based payments	0	0	0	-50 266	50 266	
KuEL-primitive payments	-1 321	0	-1 321	-24 210	22 889	1 832,7
Other indirect personnel costs	**-123 811**	**0**	**-123 811**	**-114 547**	**-9 264**	**92,5**
National pension and health insurance payments	-40 647	0	-40 647	-38 453	-2 194	94,6
Unemployment insurance contribution	-65 589	0	-65 589	-65 913	324	100,5
Accident insurance payment	-8 314	0	-8 314	-7 939	-375	95,5
Other social insurance payments	0	0	0	-1 129	1 129	
Periodic social insurance payments	-9 261	0	-9 261	-1 113	-8 148	12,0

Service purchases	**-272 257**	**-60 000**	**-332 257**	**-364 604**	**32 347**	**109,7**
Office and expert services	-200	0	-200	-12 127	11 927	6 063,5
ICT services	-65 950	0	-65 950	-66 948	998	101,5
Employee renting	-68 400	-60 000	-128 400	-158 747	30 347	123,6
Printing, announcements and advertisements	-350	0	-350	-29	-321	8,3
Postal services	-800	0	-800	-1 180	380	147,5
Insurances	-1 020	0	-1 020	-314	-706	30,8
Sanitation and laundry services	-22 737	0	-22 737	-25 815	3 078	113,5
Construction and maintenance services	-300	0	-300	0	-300	0,0
Machinery services	-500	0	-500	-3 440	2 940	688,0
Accommodation and nutrition services	-42 800	0	-42 800	-1 129	-41 671	2,6
Employee education, accom-modation and nutrition	-500	0	-500	-707	207	141,4
Traveling and transportation	-57 300	0	-57 300	-72 498	15 198	126,5
Employee education, traveling and transportation	-1 000	0	-1 000	-1 180	180	118,0
Social and health services	0	0	0	-11 462	11 462	
Education and cultural services						
Employee education and course fees	-10 200	0	-10 200	-5 091	-5 109	49,9
Other cooperation shares	0	0	0	-2 832	2 832	
Other services	-200	0	-200	-1 105	905	552,5
Materials and equipment	**-415 400**	**27 000**	**-388 400**	**-450 224**	**61 824**	**115,9**
Office supplies	-900	0	-900	-1 920	1 020	213,3
Literature	-300	0	-300	-570	270	190,0
Groceries	0	0	0	-92	92	
Clothes						

Drugs	-300	0	-300	-964	664	321,3
Caring equipment	-399 000	27 000	-372 000	-433 042	61 042	116,4
Cleaning material and equipment	-400	0	-400	-643	243	160,8
Fuel	-6 200	0	-6 200	-4 347	-1 853	70,1
Vehicles	-700	0	-700	-956	256	136,6
Other materials and equipment	-7 600	0	-7 600	-7 690	90	101,2
Other costs	**-67 405**	**0**	**-67 405**	**-70 015**	**2 610**	**103,9**
Rents of buildings	-52 963	0	-52 963	-52 044	-919	98,3
Leasing costs	-13 802	0	-13 802	-17 504	3 702	126,8
Other rents	-440	0	-440	-105	-335	23,9
Indirect taxes	0	0	0	-10	10	
Direct taxes	-200	0	-200	-300	100	150,0
Other costs	0	0	0	-46	46	
Credit lost	0	0	0	-6	6	
Total costs	**-3 071 571**	**-51 000**	**-3 122 571**	**-3 206 572**	**84 001**	**102,7**
Marginal profit	**-1 902 907**	**-13 000**	**-1 915 907**	**-1 967 437**	**51 530**	**102,7**
Write-offs						
Write-offs	**-51 000**	**0**	**-51 000**	**-29 355**	**-21 645**	**57,6**
Write-offs from computer programs	-45 000	0	-45 000	-22 307	-22 693	49,6
Write-offs from machinery	-6 000	0	-6 000	-7 048	1 048	117,5
Total write-offs	**-51 000**	**0**	**-51 000**	**-29 355**	**-21 645**	**57,6**

Profit	**-1 953 907**	**-13 000**	**-1 966 907**	**-1 996 792**	**29 885**	**101,5**
Surplus/deficit	**-1 953 907**	**-13 000**	**-1 966 907**	**-1 996 792**	**29 885**	**101,5**

	2017					
	Original budget	Budget changes	Budget after changes	Realization 1-10/2017	Deviation	Tot-%
Return						
Sales return	**681 664**	**0**	**681 664**	**560 834**	**120 830**	**82,3**
Military injury indemnity						
Other cooperation returns	681 064	0	681 064	560 168	120 896	82,2
Apprenticeship education						
Other sales return	600	0	600	666	-66	111,0
Payments	**478 000**	**0**	**478 000**	**330 425**	**147 575**	**69,1**
Other healthcare payments						
Other domestic aid payments	0	0	0	-343	343	
Other social service payments	478 000	0	478 000	330 768	147 232	69,2
Subsidies	**7 000**	**0**	**7 000**	**0**	**7 000**	**0,0**
Employment subsidy	7 000	0	7 000	0	7 000	0,0
Other returns						
Rented accommodation						
Other returns						
Total returns	**1 166 664**	**0**	**1 166 664**	**891 259**	**275 405**	**76,4**

Costs						
Personnel costs	**-2 292 211**	**43 759**	**-2 248 452**	**-1 863 580**	**-384 872**	**82,9**
Salaries and bonuses	**-1 806 678**	**35 850**	**-1 770 828**	**-1 483 802**	**-287 026**	**83,8**
Monthly salaries	-1 641 839	35 850	-1 605 989	-1 309 171	-296 818	81,5
Temporary employee salaries	-25 136	0	-25 136	-62 996	37 860	250,6
Prime costs	-165 000	0	-165 000	-151 300	-13 700	91,7
Temps during education						
Other salaries	0	0	0	-60	60	
Periodic salaries and bonuses	-18 703	0	-18 703	0	-18 703	0,0
Health insurance compensation	44 000	0	44 000	35 093	8 907	79,8
Accident indemnity	0	0	0	3 623	-3 623	
Other KELA compensations	0	0	0	1 009	-1 009	
Indirect personnel costs	**-485 533**	**7 909**	**-477 624**	**-379 778**	**-97 846**	**79,5**
Retirement costs	**-384 462**	**7 164**	**-377 298**	**-305 189**	**-72 109**	**80,9**
KuEL-salary based payments	-313 268	6 089	-307 179	-259 429	-47 750	84,5
KuEL-pension based payments	-54 960	1 075	-53 885	-45 831	-8 054	85,1
KuEL-primitive payments	-16 234	0	-16 234	71	-16 305	-0,4
Other indirect personnel costs	**-101 071**	**745**	**-100 326**	**-74 589**	**-25 737**	**74,3**
National pension and health insurance payments	-21 098	745	-20 353	-16 055	-4 298	78,9
Unemployment insurance contribution	-61 738	0	-61 738	-48 451	-13 287	78,5
Accident insurance payment	-10 992	0	-10 992	-9 166	-1 826	83,4
Other social insurance payments	-1 099	0	-1 099	-917	-182	83,4
Periodic social insurance payments	-6 144	0	-6 144	0	-6 144	0,0

Service purchases	**-297 470**	**3 100**	**-294 370**	**-365 935**	**71 565**	**124,3**
Office and expert services	-3 950	0	-3 950	-6 099	2 149	154,4
ICT services	-72 200	2 900	-69 300	-60 544	-8 756	87,4
Employee renting	-131 300	0	-131 300	-202 620	71 320	154,3
Printing, announcements and advertisements	-350	0	-350	-25	-325	7,1
Postal services	-800	0	-800	-452	-348	56,5
Insurances	-1 020	0	-1 020	-323	-697	31,7
Sanitation and laundry services	-22 000	0	-22 000	-16 888	-5 112	76,8
Construction and maintenance services						
Machinery services	-500	0	-500	-1 845	1 345	369,0
Accommodation and nutrition services	-1 050	0	-1 050	-700	-350	66,7
Employee education, accom-modation and nutrition	-500	0	-500	-405	-95	81,0
Traveling and transportation	-57 400	200	-57 200	-58 065	865	101,5
Employee education, traveling and transportation	-1 000	0	-1 000	-711	-289	71,1
Social and health services	0	0	0	-12 155	12 155	
Education and cultural services						
Employee education and course fees	-5 400	0	-5 400	-5 103	-297	94,5
Other cooperation shares						
Other services						
Materials and equipment	**-447 500**	**0**	**-447 500**	**-434 977**	**-12 523**	**97,2**
Office supplies	-900	0	-900	-601	-299	66,8
Literature	-300	0	-300	-123	-177	41,0
Groceries	0	0	0	-20	20	
Clothes						

Drugs	-400	0	-400	-588	188	147,0
Caring equipment	-434 000	0	-434 000	-427 663	-6 337	98,5
Cleaning material and equipment	-300	0	-300	-538	238	179,3
Fuel	-5 200	0	-5 200	-3 132	-2 068	60,2
Vehicles	-3 400	0	-3 400	-728	-2 672	21,4
Other materials and equipment	-3 000	0	-3 000	-1 584	-1 416	52,8
Other costs	**-52 773**	**70**	**-52 703**	**-43 143**	**-9 560**	**81,9**
Rents of buildings	-36 833	0	-36 833	-30 700	-6 133	83,3
Leasing costs	-15 440	70	-15 370	-11 497	-3 873	74,8
Other rents	-200	0	-200	-240	40	120,0
Indirect taxes	0	0	0	-352	352	
Direct taxes	-300	0	-300	0	-300	0,0
Other costs						
Credit lost	0	0	0	-354	354	
Total costs	**-3 089 954**	**46 929**	**-3 043 025**	**-2 707 635**	**-335 390**	**89,0**
Marginal profit	**-1 923 290**	**46 929**	**-1 876 361**	**-1 816 376**	**-59 985**	**96,8**
Write-offs						
Write-offs	**-29 000**	**0**	**-29 000**	**0**	**-29 000**	**0,0**
Write-offs from computer programs	-21 600	0	-21 600	0	-21 600	0,0
Write-offs from machinery	-7 400	0	-7 400	0	-7 400	0,0
Total write-offs	**-29 000**	**0**	**-29 000**	**0**	**-29 000**	**0,0**

Profit	**-1 952 290**	**46 929**	**-1 905 361**	**-1 816 376**	**-88 985**	**95,3**
Surplus/deficit	**-1 952 290**	**46 929**	**-1 905 361**	**-1 816 376**	**-88 985**	**95,3**

FEEDBACK REPORT:

	Unit	2015_2	2016_1	2016_2	2017_1
Home care customers					
Service duration					
Treatment period in days	Average	1375	1258	1282	1251
Treatment period in years	Average	3,8	3,4	3,5	3,4
Treatment period under 1 year	%	20,8	25,5	29,4	22,4
Treatment period 1-2 years	%	34,1	31,8	27	38,3
Treatment period 3-4 years	%	12,1	14,1	18,1	15,4
Treatment period over 5 years	%	32,9	28,6	25,5	23,9
Service usage					
Has received basic services per 7 days	%	70,5	70,8	67,6	66,7
In how many days per 7 days	Average	5,4	5,5	5,3	5,3
How many hours per 7 days	Average	4,4	4,4	4,6	4,5
Has received nursing services per 7 days	%	72,8	75	75	77,1
In how many days per 7 days	Average	1,1	1,1	1,1	1,1
How many hours per 7 days	Average	1,3	1,7	1,6	1
Has received home help per 7 days	%	9,8	5,7	4,4	2
In how many days per 7 days	Average	5,2	3,4	4	2
How many hours per 7 days	Average	6,8	5,2	9,2	11,1

Has received physiotherapist services per 7 days	%	8,1	7,3	5,4	6,5
In how many days per 7 days	Average	1,4	1,4	1,3	1,3
How many hours per 7 days	Average	1,3	1,4	1,5	1,4
Has received occupational therapist services per 7 days	%	0	0,5	0,5	0,5
In how many days per 7 days	Average	0	1	1	3
How many hours per 7 days	Average	0	1	1	8
Has received speech therapist services per 7 days	%	0	0	0,5	0
In how many days per 7 days	Average	0	0	2	0
How many hours per 7 days	Average	0	0	2	0
Service need (MAPLe 1-5)					
1 = Low	%	11,6	15,1	16,2	20,9
2 = Mild	%	9,8	12	10,8	8,5
3 = Moderate	%	16,2	14,6	16,2	16,9
4 = High	%	45,1	37,5	41,2	38,3
5 = Very high	%	17,3	20,8	15,7	15,4

REGULAR CUSTOMERS:

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Regular visits													
Visits in 2015			5620	5424	5295	5300	5661	5384	5522	5754	5454	6006	55420
Visits in 2016	5698	5216	5620	5588	5790	5360	5566	5490	5404	5590	5721	5691	66734
Visits in 2017	5635	5259	6086	5909	6048	5768	6092	6210	6318				53325
Regular customers													
Customers in 2015			155	145	139	142	146	148	139	146	143	155	235
Customers in 2016	173	185	178	177	180	178	180	182	180	179	186	189	262
Customers in 2017	188	189	201	196	190	182	182	196	190				260
Used time on regular visits													
Time in 2015 (hours)			1895,68	1906,92	1849,10	1874,17	1961,20	1913,15	2644,52	2002,08	1956,00	2117,17	20119,98
Time in 2016 (hours)	2005,37	1852,82	1996,57	1985,32	2025,28	1968,38	1968,72	1987,48	1963,15	1981,35	1950,68	1933,15	23618,27
Time in 2017 (hours)	1944,17	1802,73	2060,10	1916,08	1965,67	1900,43	1989,40	1964,95	2042,68				17586,22

TEMPORARY CUSTOMERS:

Month	1	2	3	4	5	6	7	8	9	10	11	12	Total
Temporary visits													
Visits in 2015			176	135	135	139	131	112	166	157	166	147	1464
Visits in 2016	51	45	35	29	22	26	24	30	27	56	75	54	474
Visits in 2017	60	65	47	25	72	80	29	48	25	57	32		540
Temporary customers													
Customers in 2015			72	64	62	72	61	53	68	73	81	68	171
Customers in 2016	31	22	23	21	13	16	19	18	20	25	42	30	136
Customers in 2017	23	31	26	18	31	32	22	25	20	31	23		140
Used time on temporary visits													
Time in 2015 (hours)			82,55	59,67	68,60	76,13	64,33	59,23	73,02	80,10	70,93	64,97	699,53
Time in 2016 (hours)	19,13	18,03	11,55	12,27	9,00	11,13	7,40	11,47	10,62	21,95	23,38	14,97	170,90
Time in 2017 (hours)	19,22	22,87	15,30	9,70	27,65	29,97	10,53	13,38	7,30	19,97	11,28		187,17

PERSONNEL:

Personnel			
Nurses	6,6		
Practical nurses	30		
Total	36,6		
Year	2015	2016	2017
Sick leaves			
Sick leaves (days)	1342	1526	1061,74
Ended employments			
Resignations	1	0	2
Retirements	0	1	0
Moved to housing services	2	0	0
Total	3	1	2

APPENDIX C: POPULATION FORECAST IN FINLAND

Population forecast 2015												
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
FINLAND	Total	5471753	5490245	5511625	5532857	5553902	5574711	5595213	5615382	5635127	5654344	5672989
	- 6	423283	420503	417389	413791	411339	409247	408456	408390	408712	408731	408430
	7 - 64	3957082	3946085	3941851	3936132	3932369	3927884	3922601	3916317	3911753	3910583	3907597
	65 - 74	615487	642818	651318	679418	695399	709830	712082	707828	700293	689826	683189
	75 - 84	341861	341624	357735	356929	366438	376572	397098	424385	451278	476070	498003
	85 -	134040	139215	143332	146587	148357	151178	154976	158462	163091	169134	175770
Case 2	Total	10610	10640	10672	10709	10744	10782	10818	10852	10883	10916	10948
	- 6	863	864	853	865	857	854	849	830	827	825	823
	7 - 64	7525	7483	7455	7421	7391	7370	7361	7348	7332	7342	7335
	65 - 74	1197	1272	1306	1375	1437	1478	1485	1500	1479	1441	1435
	75 - 84	726	709	738	727	737	752	785	839	906	944	981
	85 -	299	312	320	321	322	328	338	335	339	364	374
Case 1	Total	18689	19126	19554	19980	20396	20797	21186	21561	21921	22263	22589
	- 6	1931	1954	1953	1958	1941	1941	1950	1962	1974	1983	1989
	7 - 64	13813	14047	14316	14580	14859	15092	15309	15496	15679	15860	16017
	65 - 74	1901	1999	2048	2134	2206	2252	2260	2303	2341	2331	2351
	75 - 84	821	882	976	1015	1076	1175	1304	1412	1503	1626	1736
	85 -	223	244	261	293	314	337	363	388	424	463	496

2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
5690988	5708232	5724729	5740382	5755110	5769032	5782033	5794198	5805421	5815780	5825225
407818	406906	405741	404411	402990	401549	400169	398936	397878	397078	396527
3904610	3901511	3898267	3894318	3891061	3889057	3887169	3885543	3885455	3889323	3894146
679167	678222	675605	676201	675535	673979	671852	671165	671595	665996	659117
521526	531392	554687	568694	581376	585238	584455	581101	575170	572467	571758
177867	190201	190429	196758	204148	219209	238388	257453	275323	290916	303677
10981	11015	11051	11085	11117	11150	11180	11208	11234	11260	11282
821	817	814	810	806	803	800	798	796	796	795
7306	7285	7264	7248	7225	7227	7218	7197	7185	7172	7168
1442	1442	1456	1451	1462	1457	1450	1464	1493	1504	1490
1041	1074	1125	1177	1211	1223	1238	1229	1201	1201	1212
371	397	392	399	413	440	474	520	559	587	617
22901	23198	23481	23745	23996	24232	24457	24673	24882	25083	25274
1993	1993	1993	1989	1985	1980	1974	1969	1965	1962	1960
16138	16257	16350	16458	16523	16599	16642	16696	16745	16817	16876
2407	2471	2555	2615	2692	2754	2828	2895	2973	3011	3033
1826	1877	1954	2017	2063	2077	2118	2151	2148	2169	2221
537	600	629	666	733	822	895	962	1051	1124	1184

2036	2037	2038	2039	2040
5833881	5841730	5848884	5855444	5861491
396241	396173	396322	396623	396982
3900501	3908357	3917684	3921572	3922550
650307	639655	626793	619972	617245
573361	573749	576636	578449	579416
313471	323796	331449	338828	345298
11304	11326	11347	11367	11385
796	796	797	798	800
7169	7186	7189	7201	7210
1474	1443	1430	1403	1396
1218	1233	1235	1249	1251
647	668	696	716	728
25457	25632	25800	25963	26119
1960	1961	1964	1967	1971
16948	17015	17086	17116	17145
3040	3035	3040	3059	3092
2280	2356	2412	2482	2538
1229	1265	1298	1339	1373

APPENDIX D: CASE HOME CARE ORGANIZATION 2 DATA

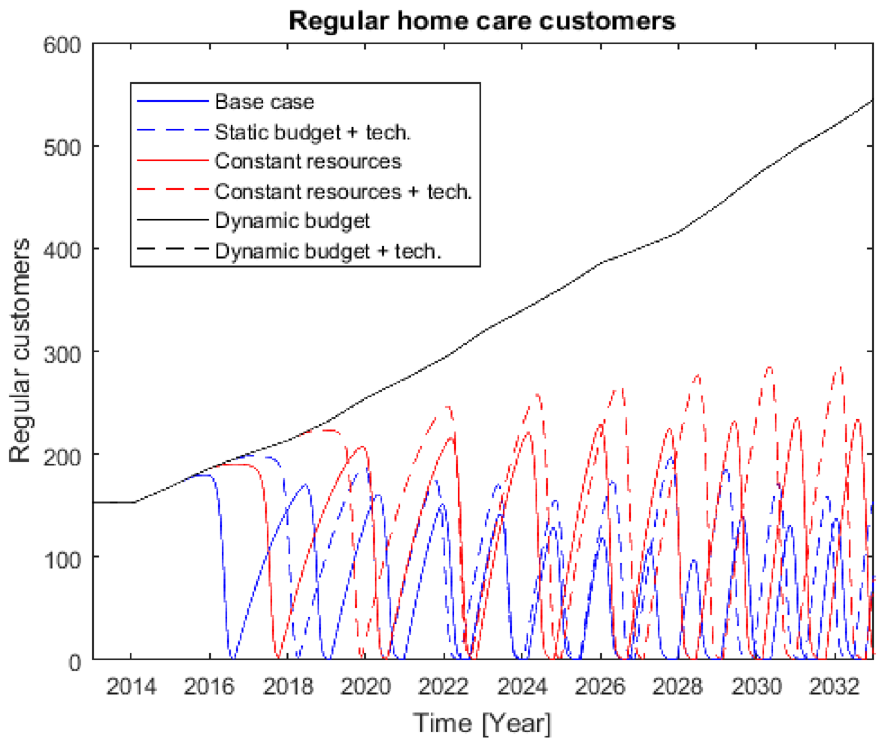
HOME CARE:

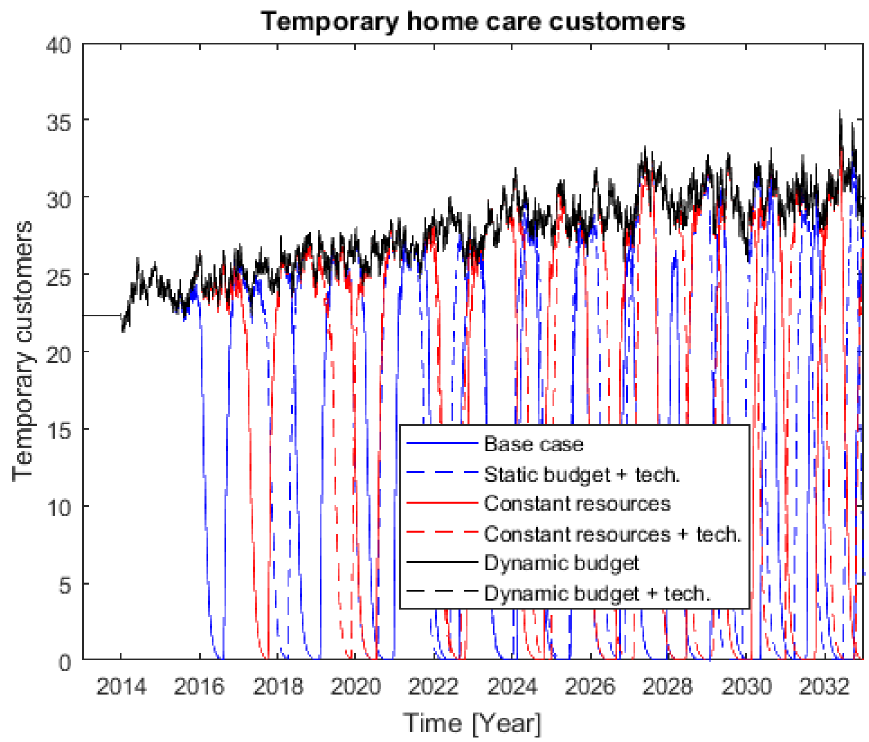
COST OF A HOME CARE VISIT IN 2016		
Gross costs of home care		1531804,00
Personnel costs	1247150	
Customer service costs	46267	
Other service costs	143799	
Material and equipment	45117	
Other costs	49471	
Other than customer incomes		10726,00
Allocations		
Municipality and SOTE central administrations		108701
Warehouse costs		4499,00
Total costs		1634278,00
Proportion of housing care 85 %		1389136,30
Housing care visits		61454
Gross cost of housing care visit		**22,60 €**
Proportion of home healthcare 15 %		245141,70
Home healthcare visits		4284
Gross cost of home healthcare visit		**57,22 €**

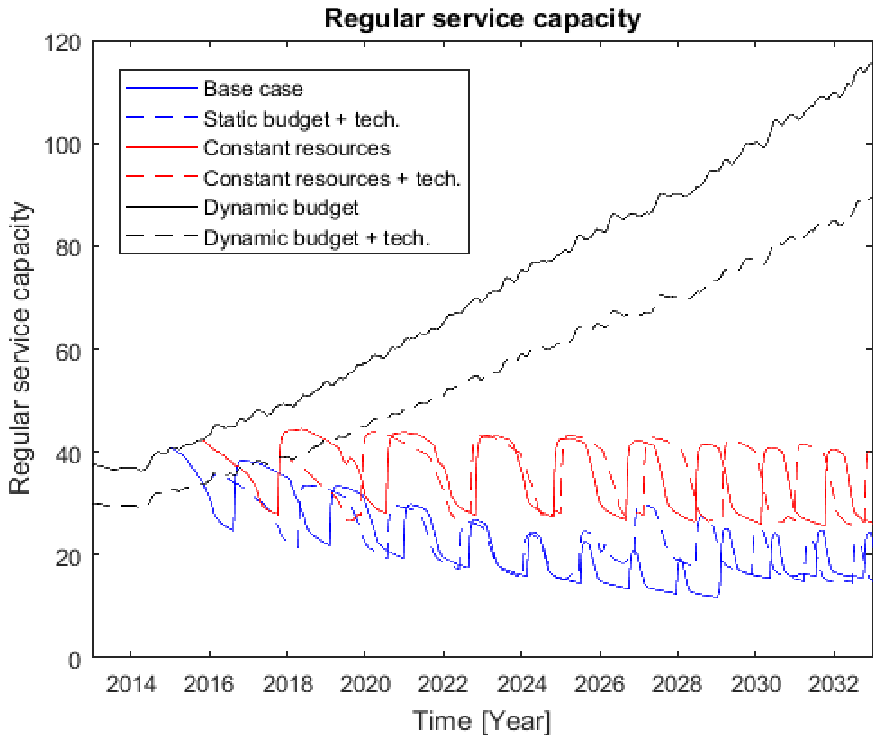
INSTITUTIONAL CARE:

INSTITUTIONAL CARE COST IN 2016 (without rent)		
Gross costs of institutional care		3380903,00
Personnel costs	2820434	
Other services costs	442945	
Material and equipment	79779	
Other costs	37745	
Other than customer incomes		295623,00
Allocations		
Municipality and SOTE central administrations		244577,00
Warehouse costs		13092,00
Total costs		3342949,00
Customer days	25511	
Daily cost of a customer		**131,04**

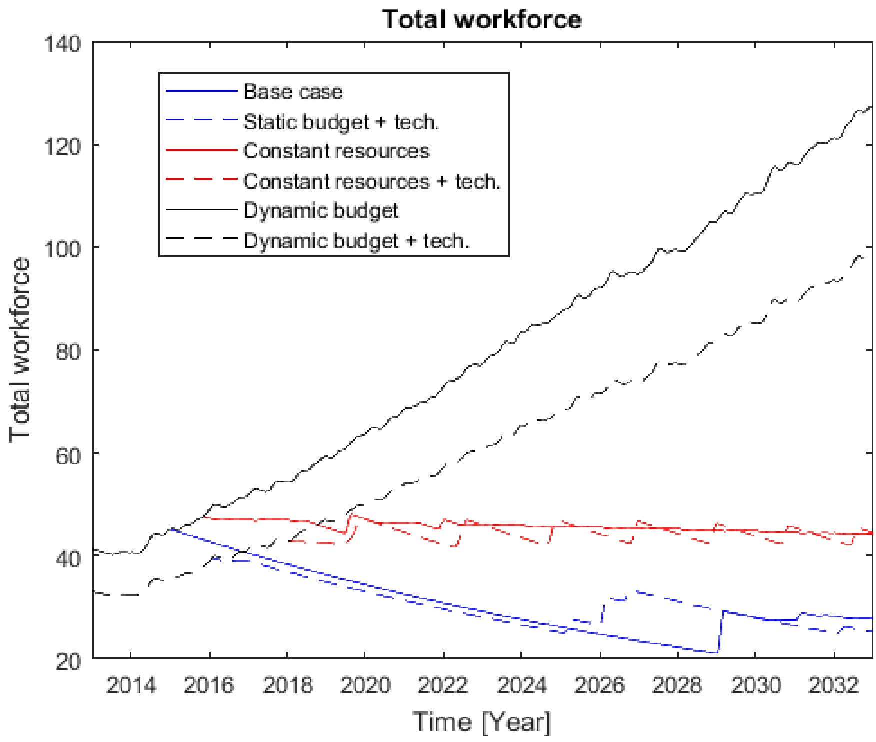
APPENDIX E: SIMULATION RESULTS



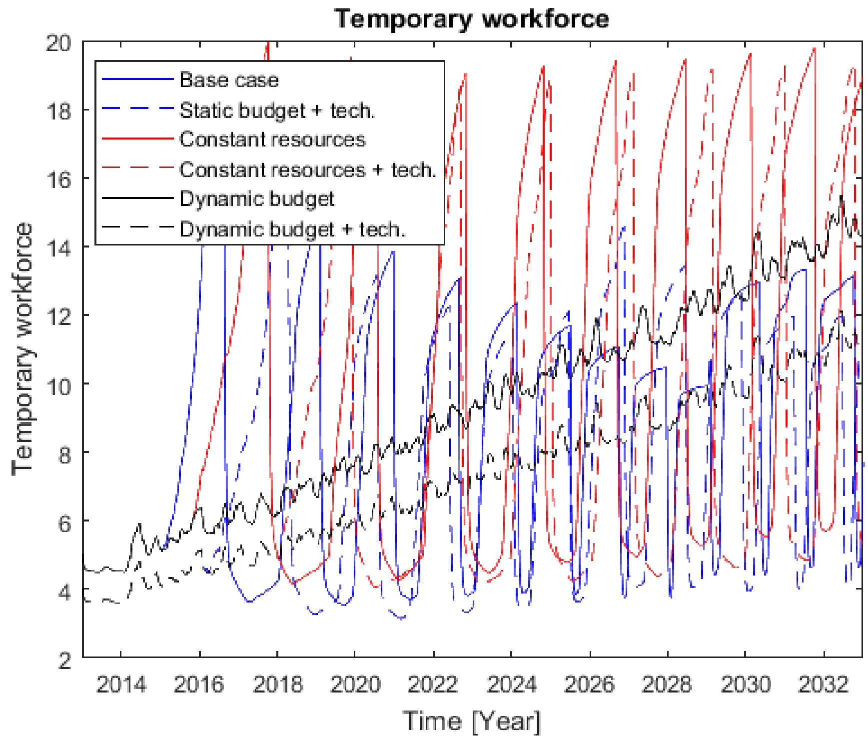


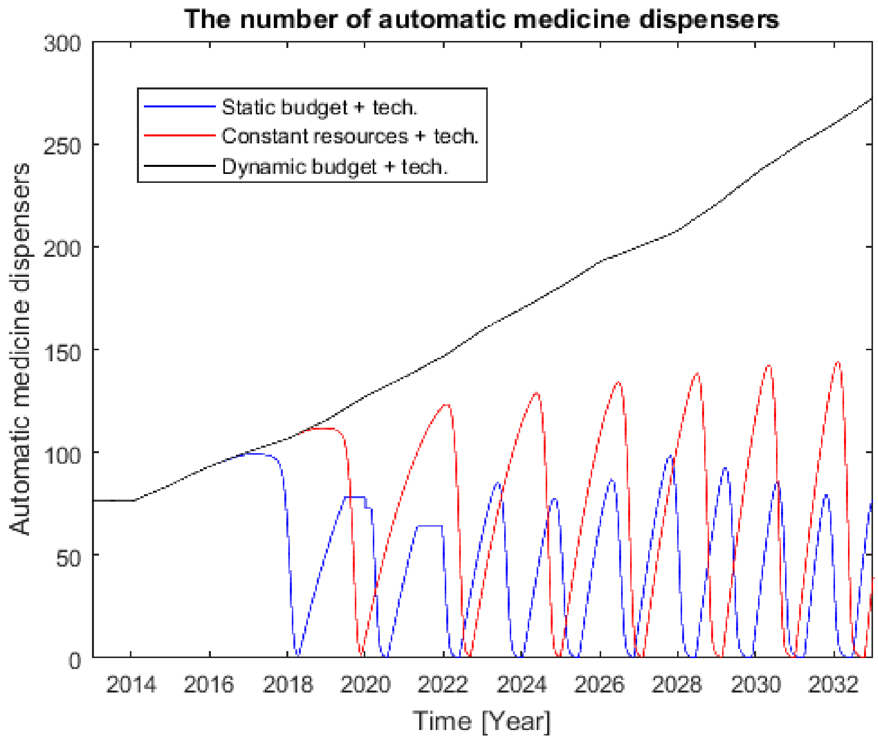


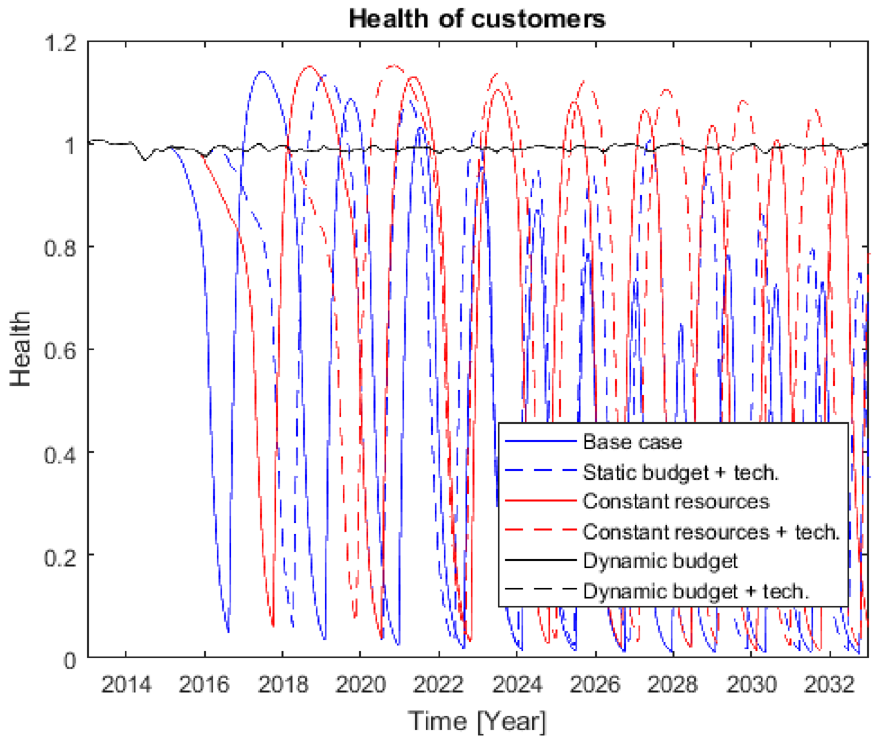
Regular service capacity
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.
Regular service capacity
120
100
80
60
40
20
0
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
Time [Year]

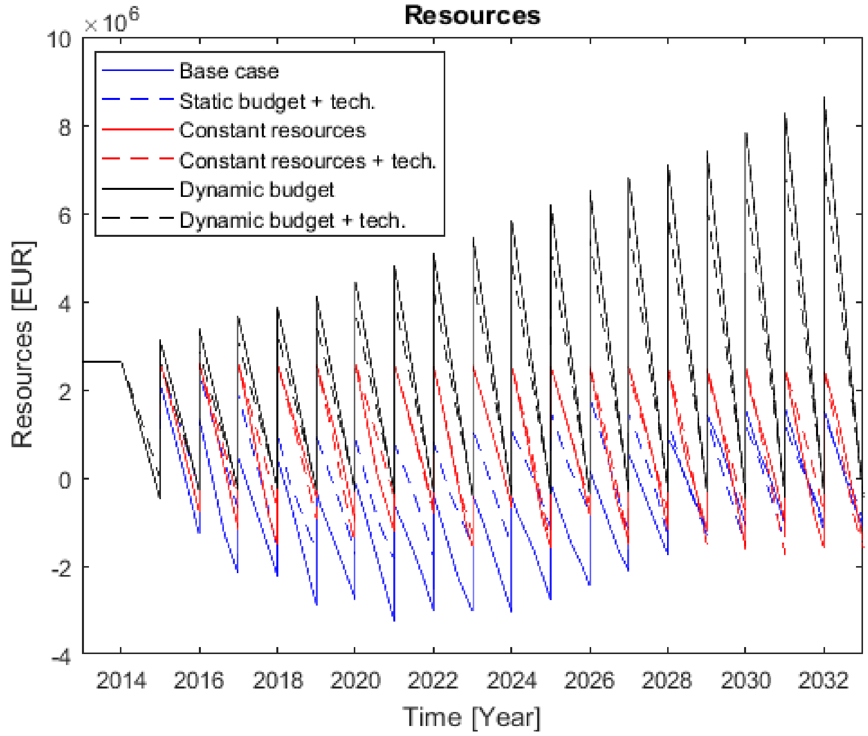


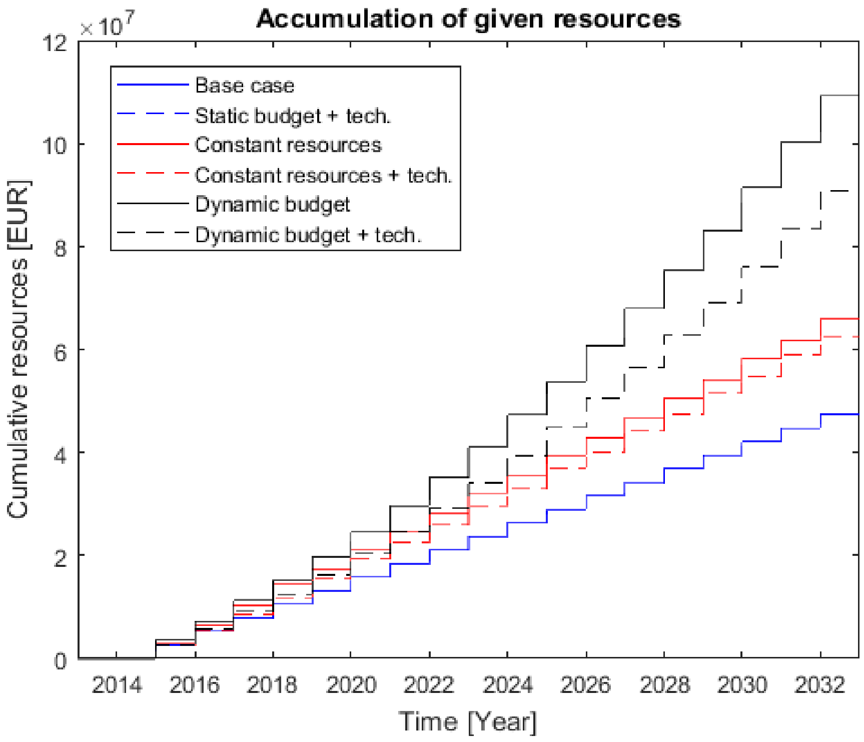
Total workforce
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.
Total workforce
140
120
100
80
60
40
20
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
Time [Year]

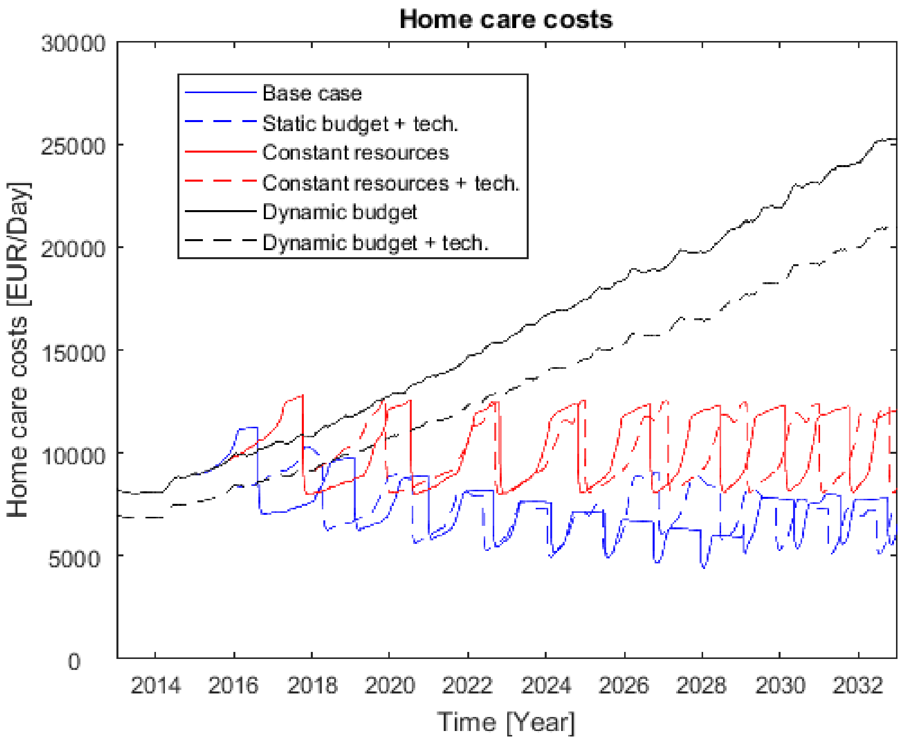

Temporary workforce
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.
Temporary workforce
Time [Year]

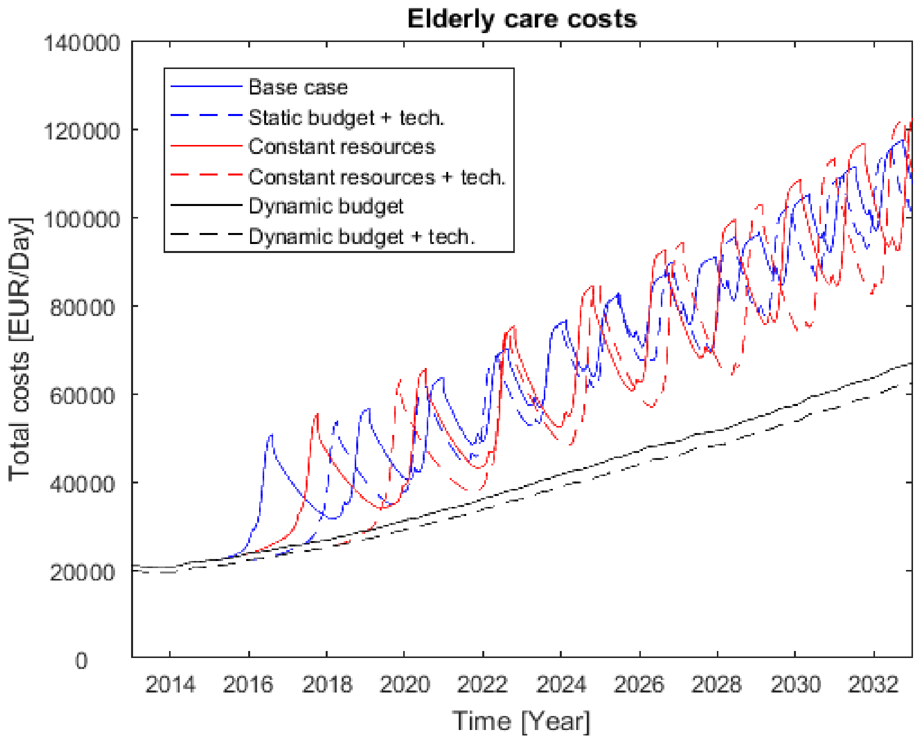

The number of automatic medicine dispensers
Static budget + tech.
Constant resources + tech.
Dynamic budget + tech.
Automatic medicine dispensers
Time [Year]

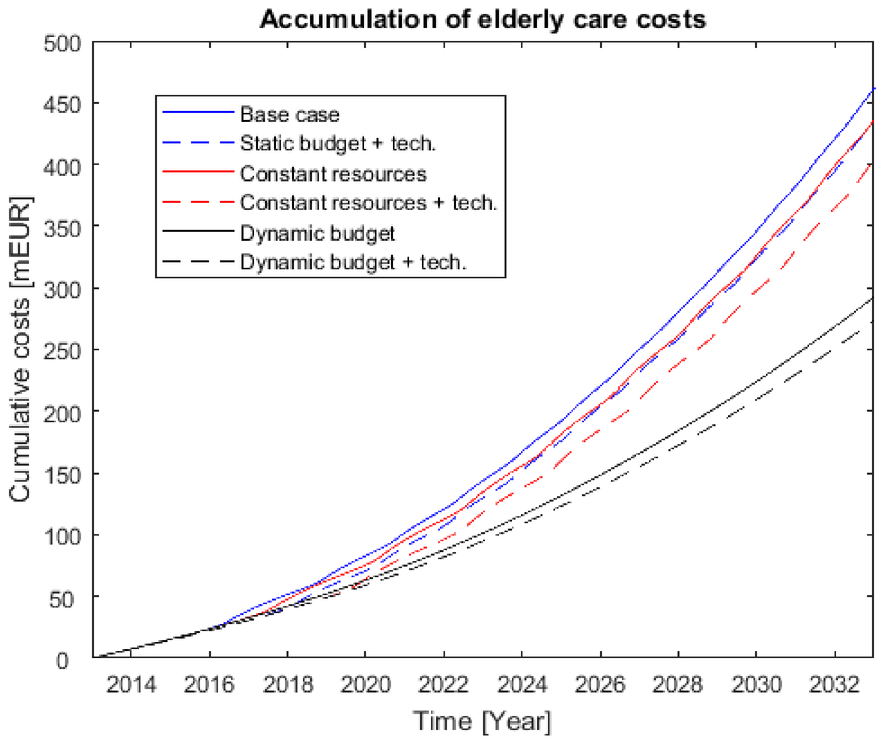

Health of customers
Health
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.


Resources
Resources [EUR]
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.


Accumulation of given resources
×10^7
Cumulative resources [EUR]
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.


Home care costs
Home care costs [EUR/Day]
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.


Elderly care costs
Total costs [EUR/Day]
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.
0
20000
40000
60000
80000
100000
120000
140000
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032


Accumulation of elderly care costs
Cumulative costs [mEUR]
Time [Year]
Base case
Static budget + tech.
Constant resources
Constant resources + tech.
Dynamic budget
Dynamic budget + tech.
0
50
100
150
200
250
300
350
400
450
500
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032