Journal of Operations Management 53–56 (2017) 9–22

Contents lists available at ScienceDirect

Journal of Operations Management

journal homepage: www.elsevier.com/locate/jom

Improving home care: Knowledge creation through engagement and design

Johan Groop[a], Mikko Ketokivi[b], Mahesh Gupta[c], Jan Holmström[d,*]

[a] Aalto University and Nordic Healthcare Group, Finland
[b] IE Business School, IE University, Spain
[c] University of Louisville, United States
[d] Aalto University, Finland

ARTICLE INFO

Accepted by: Dr. V. Daniel R. Guide

Keywords:
Design science
Problem solving
Practical problems
Health care
Home care
Theory of Constraints

ABSTRACT

In this paper, we apply a design science approach to help a Northern European city improve the efficiency of its home care delivery system. Our proposed solution emerges as a synthesis of applying Goldratt's Theory of Constraints and the principles of variable-demand inventory replenishment. The improved system exhibits both more level resource utilization and higher productivity due to more efficient capacity utilization. In addition to improving system efficiency, we gain insights into how authentic operations management problems can be addressed through design research. A crucial aspect of empirically-rooted practical problems is that they always involve multiple stakeholders with only partially overlapping preferences. Consequently, one must not assume or ascribe an *a priori* system objective, instead, it must arise from explicit empirical analysis of the relevant stakeholders. Another characteristic of authentic problems is that they are always embedded in an institutional context that sets significant boundary conditions to the feasibility of solutions. These boundary conditions are an important reminder of the complexity of empirically-rooted managerial problems.

1. Introduction

If Mrs. Johnson has to move into an assisted-living facility because she needs help with her daily insulin injections, everybody loses. As we get older, living in our own homes as long as possible is not only a matter of personal preference, it is also more cost effective for cities and states to develop systems and infrastructure to promote assisted home living. If successful, such promotion lowers the unnecessary influx of senior citizens into assisted-living facilities and the health care system more generally. With this general objective in mind, the city of *Espoo*, the largest suburb of Helsinki, Finland, reached out to us for help in designing and improving a city-wide home care system. The pressing problem stemmed from baby boomers reaching the age where they required assistance in increasingly larger numbers, yet, the resources allocated to home care had not increased proportionately. The system would need to be more efficient to ensure the requisite quality of care.

The key questions regarding the design of the home care system fall squarely in the domain of operations management (OM) research (e.g., Eveborn et al., 2006; Eveborn et al., 2009): How should the daily travel routes of nurses be planned? How should overall caregiver capacity allocation be planned? These are the questions we were asked to address. Our task was to help build, evaluate, and, if needed, redesign *a home care delivery system*.

The extant literature on the topic is commendable as it has led to many improvements of the home care system particularly in the Scandinavian countries (Eveborn et al., 2009) and the *Benelux* countries of Belgium, the Netherlands, and Luxembourg (Duque et al., 2015). Of course, the problem is not limited to these countries, as scholars in the United States have observed similar challenges in the organization and coordination of home care (e.g., Osborn et al., 2014). We seek to complement this research by focusing on the problem in the authentic field setting. This is important, because a common denominator in much of the research literature on home care is that the problem and the objective are taken as given:

> "When viewing the daily planning as a scheduling problem, the objective is to create a schedule that allocates visits to staff members. The efficiency of the plan is judged by the amount of travel time it requires and how well it has succeeded in allocating all visits to staff members. The quality is judged by how well continuity is kept with staff member visits to each client." (Eveborn et al., 2006: 964).

The premise embraced in this passage is echoed in much of the literature on home care systems. The underpinning assumption is that the nature of the problem and the objectives are *a priori* known (Begur et al., 1997; Duque et al., 2015; Yuan et al., 2015). But how problems

* Corresponding author.
E-mail addresses: johan.groop@nhg.fi (J. Groop), mikko.ketokivi@ie.edu (M. Ketokivi), mahesh.gupta@louisville.edu (M. Gupta), jan.holmstrom@aalto.fi (J. Holmström).

https://doi.org/10.1016/j.jom.2017.11.001
Received 8 November 2015; Received in revised form 31 August 2017; Accepted 9 November 2017
Available online 21 November 2017

become framed and which objectives become important is an essential part of any problem-solving process (Mingers, 2011; Mingers and Brocklesby, 1997; Simon, 1997). To declare travel time and continuity as the key objectives of the home care system is straightforward but lacks empirical rigor. To clarify, this is not to say that these are the wrong objectives, the point is that objectives, whatever they may be, must be established through explicit analysis, not by assumption or declaration. Authentic field problems tend to involve several stakeholders whose objectives and preferences are only partially overlapping. Our stakeholder approach parallels the approach taken by Freeman et al. (2010: 24):

> "Business can be understood as a set of relationships among groups which have a stake [hence, *stake*holder] in the activities that make up the business. Business is about how customers, suppliers, employees, financiers (stockholders, bondholders, banks, etc.), communities, and managers interact and create value. To understand a business is to know how these relationships work."

This stakeholder approach is appreciably similar to the approach taken in recent OM literature on sustainability, for example (Gualandris et al., 2015; Sarkis et al., 2010).

In a home care setting, considering stakeholder issues is crucial, because only by sheer miracle would the aspirations and the objectives of the diverse stakeholder groups—customers, caregivers, management, and the service provider—readily align (e.g., Cyert and March, 1992). To be sure, Mrs. Johnson certainly has preferences that would be at least partly in conflict with economic efficiency considerations. More generally, tensions between quality and efficiency in health care systems are well known and documented (Payne, 2006). In the home care context, an effective solution must be based on an understanding of these tensions. To ascribe *a priori* an unambiguous common set of objectives is to ignore these realities (Davies et al., 2005).

This paper has two aims. The main objective is squarely practical: to help the practitioner design a more effective home care system and to demonstrate that this design improves system performance. This involves an attempt to find solutions to resource allocation and efficiency problems that had proven very difficult prior to our involvement. The secondary objective is academic: to understand the important role that problem framing plays in how academics approach practical problems. Specifically, our aim is to unearth some of the underlying assumptions we tend to take as given. Of course, the idea that problem framing is fundamentally conditioned by our knowledge of the available solutions is not new (Cohen et al., 1972; Gigerenzer, 1991; Sarasvathy, 2001). However, we are able to explicate and elaborate what this means in a specific empirical setting. In particular, we show how in an authentic practical setting the attempt at a solution changes how the problem is framed. In addition to tackling the practical problem and seeking solutions, we also want to understand the dynamics of problem framing and solutions in an authentic setting. This in turn could lead to a better understanding of design science research in OM (cf. Holmström et al., 2009; van Aken et al., 2016).

The starting point of our research effort is that the practitioner's problem does not exist "out there", but rather, emerges as the result of a complex, iterative process of *framing* and *design* where the researcher plays a crucial part (Simon, 1997). Consequently, as part of our research effort we apply various tools that help us understand framing in particular. These tools take into account that in managerial practice, problems and solutions do not have a well-defined linear relationship in time. To use Corbett and Van Wassenhove's (1993: 626) terminology, solving a real-life problem is primarily a *management engineering* effort, which focuses on the engineering of a solution as opposed to mere application of existing solutions to *ex ante* identifiable, well-defined problems, where problem definition unambiguously precedes the attempts to solve it. The home care problem we faced was *ill-defined* (Simon, 1973) and *wicked* (Churchman, 1967). The latter is described as a "class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Churchman, 1967: B141).

The paper is organized as follows. We first discuss how the city first perceived and framed the problem, how we got involved, and how we approached the problem. After describing the data collection, problem framing and solution design efforts, we present the key results and limitations. To conclude, we turn to a more reflexive examination of the academic's role in solving practical problems.

2. Research context

The practical problem addressed is the organization of home care in Espoo, a city of 250,000 people in the Metropolitan Helsinki area in Finland. The initiative in question, *Espoo Home Care (EHC)*, provides a range of medical (health care and hospice), daily routine (e.g., bathing, grocery shopping), and social (e.g., transportation) services to senior citizens. Those providing the actual care—the visiting caregivers—are health care professionals, typically either registered nurses or licensed practicing nurses. Caregivers travel daily from home to home, applying their diverse skills to deliver whatever care the customer might need. EHC is largely a publicly funded effort, with 90 percent taxpayer contribution. The remaining 10 percent comes from income-adjusted copayments from those who use the service, which we label *customers*.

EHC was established in 2006 as a result of the merger of five separate but geographically collocated units. At the time of our involvement, EHC consisted of two major districts with nine caregiver teams of 12–26 caregivers in each district, a total of a few hundred caregivers. At the inception of our involvement, the system was decentralized in that caregiver teams operated more or less independently. This resulted in heterogeneous operational practices and resource allocation principles across teams. Much of the action was at the team level.

EHC is operationally complex for three reasons (cf. Eveborn et al., 2006). First, care is given in the field, delivered at people's homes instead of a centralized location. Second, individual customer needs are highly variable: one customer might need assistance with personal hygiene and administration of non-time-critical daily medication; another might need help every day just to get in and out of bed and time-critical medication such as insulin shots or pain relief. Sometimes the customer is for all practical purposes also a patient, but at the same time, medical care is only one of the services provided—*customer* is a better general label. Customer is also a better label, because in the focal context, the concept of home care encompasses not only health care but also other services such as social support. Third, demand for services is like demand for taxis, that is, peaks during certain times of the day and idle capacity during others. Caregivers can work in shifts, such that more capacity can be allocated to shifts with higher overall demand. At the same time, capacity is for all practical purposes a fixed cost, because in the focal context, caregivers are salaried employees whose salaries constitute roughly 85 percent of the total system cost. Use of temporary workers is possible but in practice prohibitively expensive. The quality of care provided by temporary workers is also generally considered to be of lower quality, not because temporary workers do not have the requisite skills but because using them disrupts continuity of care. The operational challenge thus arises from complex logistics combined with management of diverse and temporally fluctuating day-to-day customer needs in a high fixed-cost environment.

2.1. What, exactly, is the problem? understanding framing

In his classic book *Administrative Behavior*, Simon (1997: 126, emphasis added) discussed the perceived supremacy of Japanese manufacturers in the 1970s and 1980s:

> "[Was] the problem one of quality control, of manufacturing efficiency, of managerial style, of worker motivation, of wage levels, of

exchange rates, of foreign trade regulations, of investment incentives? The list is endless; and *different proposals for solutions correspond to different representations of the problem*."

That the list is endless does not mean that we have yet to discover what the problem was. Rather, it means that the problem is not a characteristic of the system under scrutiny, it is the outcome of a framing process: in approaching a problem, the starting point is *what the problem-solver knows* (Sarasvathy, 2001). Given this expressly subjective foundation of what we know, it is both predictable and well documented that different individuals have different perceptions of the same phenomenon (e.g., Dearborn and Simon, 1958).

Returning to the home care problem, the introduction of this paper does not describe a problem as much as it outlines a number of general concerns regarding the organization of home care in EHC's empirical context. Nothing so far has explicated what the problem is. Of course, one way to frame the home care problem is to think of it as a capacity utilization problem, which would lead us to focus attention to how the total caregiver capacity in a planning period should be allocated. An often-used operational metric for this in the home care context is *touch time*: the fraction of the total work time visiting caregivers provide actual care ("touch" customers). Factors that lower touch time are travel time, various administrative duties, statutory breaks, and unexpected delays.

When we became involved, the key decision-makers had indeed framed the problem as one of touch time optimization. Benchmarking with private providers in particular revealed that EHC's touch time of roughly 40 percent could be improved considerably. Some private providers were able to sustain levels exceeding sixty percent. This gave EHC enough material to frame the problem and provide the necessary motivation. Comparing the EHC touch time metric to private providers gave EHC management the reason to conclude their system productivity should be improved.

To conclude that how EHC management frames the problem is equal to what the problem is and how it should be addressed would be trivializing the empirical complexity. Up to this point, we had not talked to a single other relevant stakeholder group, most importantly, caregivers or customers. Would touch time optimization serve their interests and objectives? If not, what would be important from their point of view? What, if any, are the inherent conflicts in the interests of the different stakeholder groups? What unintended, undesirable consequences would focusing on touch time optimization have? This is where our informal discussions with EHC management ended and the formal empirical inquiry started.

2.2. Research design: engagement and thinking process

Upon embarking on the project, we quickly realized that the practical problem we were addressing was indeed ill-defined and wicked. The undesirable state of the system, which prompted the city to contact us, was poor touch time performance. But this was only a symptom, not the problem. Indeed, we had considerable difficulty understanding the root cause of the low touch time. We also realized that there were several actors in the system whose objectives did not readily align. For instance, customers understandably tend to prefer that the same individual caregiver visit their home every time. After all, would you want a different person give you a bath every week? But to impose dedicated caregivers to customers in route planning would immensely complicate the already very complex resource allocation process. We also realized that different actors had equivocal views not only on the objectives but also on the decision-making principles. Caregiver team discretion was a good example: EHC managers preferred centralization, caregiver team leaders preferred decentralization.

We decided that in order to do justice to the ill-defined nature of the problem and to incorporate multiple stakeholder perspectives, we had to cast a wide net in terms of data collection (Fig. 1). To this end, we collected data on EHC through interviews, direct observation, load analysis, and performance analysis. We further engaged several stakeholder groups, most notably managers who directed the EHC operation and the caregivers who provided the actual care. A project team was established to address the problem framing and solution design. The team consisted of seven members, including the Head of EHC, a service manager, the primary user of the EHC operational planning system, a financial controller, an IT system specialist, and the lead author of this paper. Five of the team members had prior experience of working as caregivers, and a deep understanding of the current solution design from a health professional's perspective. We, the researchers, managed the project and took the lead in data collection and analysis. The steering group included representatives of the project team, EHC's Director of Social and Healthcare Services, Director of Finance, Director of Elderly Services, and a union representative. This meant that many different stakeholders were represented throughout the effort. The team met regularly, either monthly or weekly, but in some phases even daily.

All the data collected by the team were analyzed by the researchers

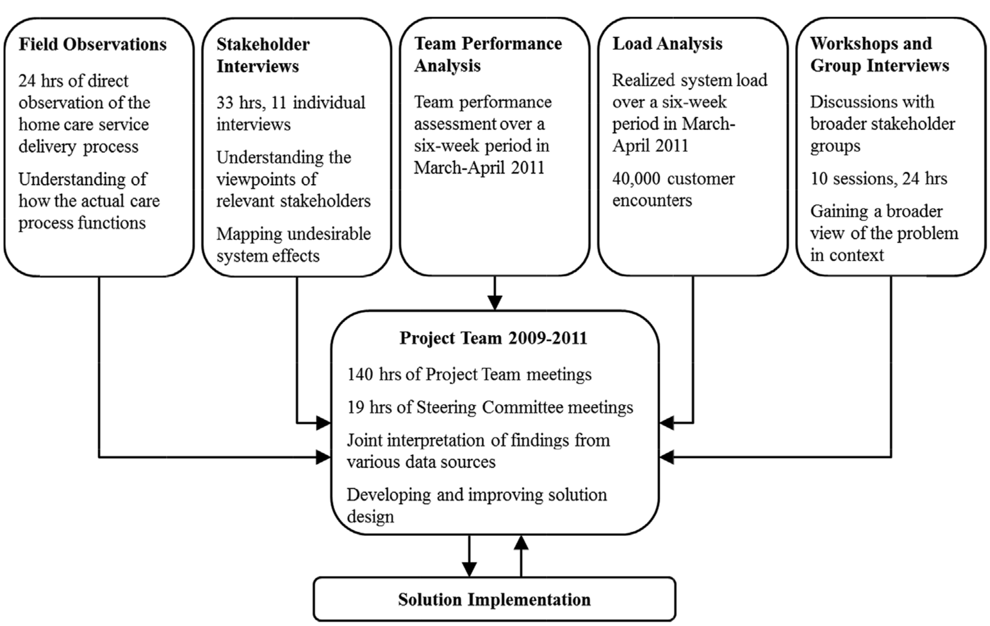

Fig. 1. Researcher engagement, problem framing, and solution development.

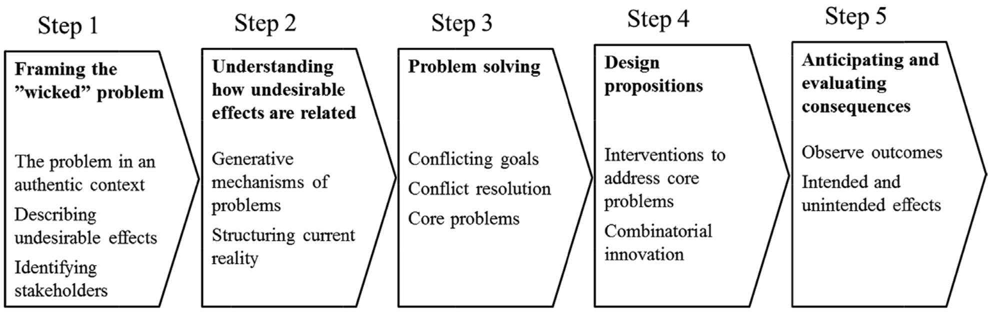

Fig. 2. Our process of problem framing and solution development.

and then jointly interpreted with the team so as to achieve the completion of the problem framing and initial solution design. These were then further analyzed and discussed in workshops and follow-up interviews with the broader set of stakeholders.

The research process in which the framing and solution design took place is best described using the *CIMO logic* found in the design science literature. CIMO logic describes "what to do [Intervention], in which situations [Context], to produce what effect [Outcome] and offer some understanding of why this happens [Mechanisms]" (Denyer et al., 2008: 396). Note that CIMO is only an abbreviation and does not presuppose or prescribe the specific sequence in which these activities occur. Indeed, an examination of the intertemporal aspects of these activities can lead to insight.

We used the *Thinking Processes tools* in our problem framing and design process. Thinking Processes are Theory-of-Constraints (TOC) tools (Dettmer, 1997; Goldratt, 1990), where the idea is to collect and analyze data from a system so as to fully understand it. One of the idiosyncratic features of Thinking Processes is that the starting point is the identification of a set of *undesirable effects* observed in the system. Recall that the objective is not to design a system anew but to improve an existing one: EHC is not our initiative and it was already operational when we got involved. It is logical that improvement efforts start at identifying what is wrong (or sub-optimal) in the way the system is currently designed.

Goldratt (1994) initially introduced Thinking Processes to provide at least some structure to ill-structured problems. These tools are part of a wider multi-methodology research framework that combines different types of analysis and modeling for solving practical problems (e.g., Mingers and Brocklesby, 1997). Davies et al. (2005) in particular have demonstrated the complementarity and fit of Thinking Processes with OM. We build on this complementarity by applying a design science research approach and the CIMO logic in both framing and solving the problem (Fig. 2).

3. Problem framing and solution design

In this section, we describe the problem framing and solution design in detail by going through our five steps of problem framing and solution design: (1) Framing the "wicked" problem; (2) Understanding how undesirable effects are related; (3) Problem solving; (4) Design propositions; and (5) Anticipating and evaluating consequences.

3.1. Step 1: framing the "wicked" problem

The Thinking Process begins by asking the question "What to change?". This is followed by questions "To what are we changing?" and "How do we bring about the change?" (Watson et al., 2007). In approaching our informants—whether it was by interviews, direct observation, or various workshops—we started at the simple question: From your point of view, what is wrong with the current system? The different stakeholder answers to this question provided a rich view of the current home care operation (see Table 1). Understandably, the answers given by the different stakeholders reflected the idiosyncratic challenges and problems that the specific stakeholder faced in his or her daily routines. Caregivers struggled with ensuring they arrive at the customer's home on time, neither too late nor too early. Caregiver team leaders in turn wrestled with getting stand-ins on a short notice when a caregiver calls in sick. EHC managers focused more on the system-level issues such as efficiency, touch time, and overall capacity utilization. But all stakeholders were able to identify at least something they thought was wrong with the system.

Based on the stakeholder answers, the project team was able to evaluate and classify them. This analysis led to a list of eight key observations—identified *Undesirable Effects*[1]—which we thought adequately summarized the various problem representations:

1. The ratio of throughput to total labor capacity is poor.
2. Many visits are needlessly scheduled in the morning.
3. The caregivers experience high levels of stress, during peak times in particular.
4. A high level of caregiver absenteeism frequently creates unanticipated team-level capacity shortages.
5. Expensive external labor is leased to cope with capacity shortages.
6. Idle "bench capacity" in the afternoons leads to inefficiency.
7. Leasing labor further increases bench capacity in the afternoon.
8. Caregivers are "stuck in their teams" and cannot transfer to teams facing caregiver shortages.

These eight Undesirable Effects suggest serious inefficiencies in both the availability and the allocation of resources, although at this point it is important to avoid drawing conclusions about underlying causes: Undesirable Effects are symptoms, not causes. It is important to identify them, because they ultimately provide insight on what kinds of interventions are likely more effective than others. Undesirable Effects are also not defined once and for all, the list can be modified based on findings that occur later. In fact, the last Undesirable Effect on the list was added when the solution design was already underway and the specific effect became observable.

3.2. Step 2: understanding how undesirable effects are related

Having taken stock of the Undesirable Effects, the next logical step in the analysis is to examine how they are related and which effects drive others. In Thinking Process terminology, this calls for the construction of the *Current Reality Tree*, a depiction of the cause-and-effect relationships among the Undesirable Effects. In order to determine what needs to change in the system and how this can be achieved, these relationships must be understood.

Constructing the Current Reality Tree involves a logical analysis of the symptoms: Which symptoms could be driving others and in what order? The process started with drafting the initial version based on the analysis of the Undesirable Effects. This initial version was then refined

[1] This section uses Goldratt's Thinking Process terminology extensively. All Thinking Process terms, such as Undesirable Effects and Current Reality Tree, appear in *italicized Title Case* on first use and in Title Case thereafter.

Table 1
Gaining insight into the stakeholder issues.

Source	What is the problem or issue?	Whose problem is it?
Project team	"The costs are too high. We can't keep increasing labor to match increasing demand. The cost of one hour of service is already too high; higher than that of the home care service we buy from private service providers."	System planner
	"I get calls from the unions all the time, saying that they've been contacted by caregivers who are stressed out."	Management
	"The touch time is too low. I don't know how we are supposed to make it higher. We've been talking about this for years."	System planner
	"We spent more than a million euros on leased labor in 2008."	Financier
	"High level of caregiver absenteeism frequently creates unanticipated team-level capacity shortages."	System planner
	"If you need a caregiver in the morning you will typically have to employ them for the entire shift."	System planner
Observation	"We always try to cut travel time. We plan the work lists accordingly."	Team leader
	"I go from one customer to the next on foot. Of course I wouldn't take a longer route than I need to."	Caregiver
	"It's not like we're not doing anything in the afternoon. We have all kinds of tasks at the office."	Caregiver
Interviews	"We are short on staff. Sometimes I have to *run* from one customer to the next. I can forget about maintaining a rehabilitative approach. We're pretty much forced to do stuff quickly for one customer and rush to the next. That doesn't feel good."	Caregiver
	"Our worklists leave room for discretion. I sometimes change the sequence of the visits to save travel time."	Caregiver
	"They say I need to increase my own touch time, but I'm tied up getting a temp up to speed on customers needs."	Caregiver
	"If you work shorter shifts, say 4 or 6 h, you get less statutory breaks. You get less pay and the work is more intensive."	Caregiver
	"Some days are really bad. There is a demand peak and all of a sudden several team members call in sick."	Team leader
	"Temps are impossible to get on a short notice. I sometimes get some in advance just in case somebody calls in sick."	Team leader
	"It's almost impossible to find someone to only work mornings. Most caregivers want to work full shifts, even those who work part time. They ask for full shifts and then full days off. Even part-timers want full shifts."	Team leader
	"We talk about not doing non-time-critical visits during peak hours. But many times the caregivers don't follow this. They change the sequence of visits themselves."	Team leader
	"When you visit one of our offices in the afternoon, you can see that the caregivers aren't necessarily as busy as they claim."	Management
Workshops	"We used to be able to focus on caring for our clients. These days management only cares about touch time. I don't care."	Caregiver
	"Customers who don't need care every day are likely not time critical. But we have already scheduled them to the afternoon."	Caregiver
	"We need more flexibility. Sometimes our customers are hospitalized but we don't know when they return home."	Management
	"Sometimes we borrow a caregiver from another team, but mostly we have to make do with what we have."	Team leader

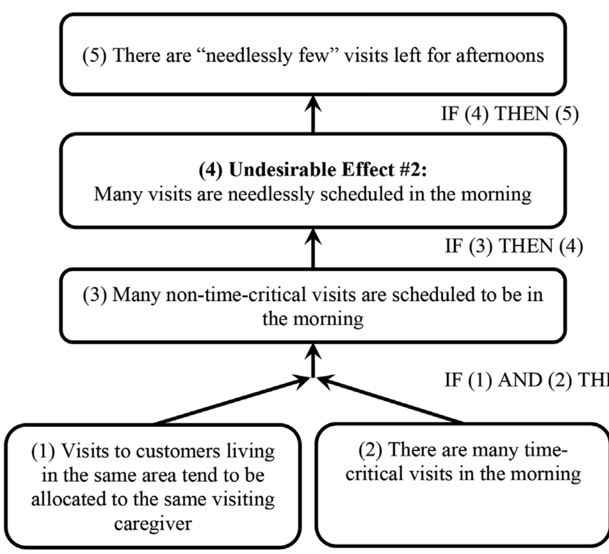

Fig. 3. Part of the current reality tree.

through iterations that involved the project team and the broader EHC organization attending workshops. Importantly, after the eighth Undesirable Effect was added, this step was revisited and extensively iterated in the project team.

The entire Current Reality Tree is too complex to depict in a single graph, but in order to illustrate the methods and the result, part of the tree that traces the determinants and consequences of the second Undesirable Effect "Many visits are needlessly scheduled in the morning" is depicted in Fig. 3.

Note the difference between "many visits scheduled in the morning " and "*needlessly* many visits scheduled in the morning." This is not semantics: the latter directly implies that the problem-solver envisions a feasible way of allocating capacity that can lead to more effective capacity utilization. For a design scientist, "many" and "needlessly many" are two entirely different things: the latter calls for an intervention, the former does not. The reason the morning shift is unnecessarily overloaded arises from the fact that many non-time-critical visits are scheduled to be in the peak hours of the morning. The Undesirable Effect of "Many visits are needlessly scheduled in the morning" links, either directly or indirectly, to other Undesirable Effects as well. For instance, it is easy to see how unduly overloading the system in the morning could lead to caregiver stress during peak hours, the third Undesirable Effect.

Why does this happen? This is where problem framing becomes particularly relevant. The root cause of the current (undesirable) reality of overloading the system in the morning hours arises from framing the problem as a routing problem. When the planning system is used to minimize travel time, the algorithm lumps the time-critical visits of the morning together with the non-time-critical visits whenever non-criticals happen to be geographically collocated with the criticals. This is of course also common sense: "If I am going to visit Mrs. Johnson to administer her insulin shot at 8 a.m. (time-critical visit), might as well stop by to see her neighbor Mr. Holmes as well, to help him with a personal hygiene need (non-time-critical visit)." But it should be obvious that this "might as well" -thinking lures the caregiver, the team, and ultimately the entire system into a sub-optimization trap. No matter how tempting it would be to help Mr. Holmes next door with laundry, the most important fact from the system point of view is that laundry is not time critical.

An important interim conclusion is that minimizing travel time is not the most meaningful way to frame the logistical problem. Instead, one needs either a more sophisticated routing algorithm which takes time criticality into account or shift to an entirely different framing. The problem with the routing framing is that it would need to be extended considerably to tackle the home care problem in all its complexity. Not only are there multiple teams of caregivers, but they also have different skill sets. Second, customer homes have to be prioritized based on time criticality. Third, travel times from location to location vary depending on the time of the day: a trip that takes thirty minutes during rush hour may take ten minutes during off-peak hours. Obviously, early arrival at the customer's home may be just as problematic as being late. Fourth, continuity of care is important: even though having dedicated caregivers is infeasible, the system can certainly do at least something so as to minimize the number of caregivers visiting a given customer's home.

Any one of these four factors is alone sufficient to make the problem difficult, if not impossible, to solve analytically. Sophisticated optimization approaches—taking into account criticality, time windows, required caregiver skills, customer preferences, and cost constraints—are difficult to implement and frequently fail to solve the problem. Even when these optimization approaches are technically feasible, they require daily inputs from the field to be useful (Duque et al., 2015).

Establishing causes and effects is always challenging, but there are a number of well-established Thinking Process techniques that are useful. Dettmer (1997) in particular presents a set of rules called *Categories of Legitimate Reservation*. These rules are applications based on various forms of logical reasoning, logical fallacies in particular; they also incorporate *counterfactual reasoning* (Morgan and Winship, 2007) in various forms. In applying these rules, we asked questions such as

1. Is there a direct and unavoidable connection between the proposed cause and effect?" (applying the *Causality Existence* rule);
2. Could cause and effect be in fact reversed? (*Cause-Effect Reversal* rule); and
3. Is the mere existence of the proposed effect enough to establish the proposed cause? (*Tautology* rule).

These rules are not novel, indeed many of them can be found in Aristotle's ([~300 BCE] 1923) *Organon*. It should be noted, however, that applying these rules is not just a reasoning exercise among the researchers. Indeed, we engaged both EHC management and operational personnel in project team and workshops interactions to assess the validity of the Current Reality Tree. The research project and data collection performed in preparation for this paper is described in detail in Groop (2012).

3.3. Step 3: problem solving

The aim of constructing the Current Reality Tree is to arrive at the *Core Problem* for the identified Undesirable Effects. In the EHC study, we concluded that, paradoxically enough, the Core Problem linked to the way in which one of the key sub-problems was framed. The problem was not how the system is managed, but lay deeper in the rules and assumptions on which it was designed. In short, the objective of minimizing travel time is intuitive but misguided. While it frames the problem as one with an unambiguous objective which lends itself to OR-based tools, the actual authentic problem does not have an unambiguous objective. Solving an idealized, simplified problem does not solve the actual practical problem. It should also be noted here that Undesirable Effects are almost always stakeholder specific in the sense that even though a given effect is properly thought of as a system-level characteristic, its manifestations are local, affecting only a subset of stakeholders. Caregivers experiencing a high level of stress during peak hours is a good example: there is a systematic effect observed in the system (many caregivers experience stress), but it affects primarily one stakeholder group, the caregivers. Of course, the indirect impact of Undesirable Effects is often felt by other stakeholder as well.

Solving the Core Problem starts at incorporating the understanding gained from the Undesirable Effects, the Current Reality Tree, and the problem framing to construct the *Conflict Resolution Diagram*, sometimes called the *Evaporating Cloud* (Goldratt, 1990). The idea is to examine the potentially conflicting actions, needs, and objectives. In constructing the Evaporating Cloud, the assumptions underpinning the Thinking Process are explicated and brought to critical analysis. This critical examination may point to potential interventions or design propositions that "evaporate" the conflict. Construction of the Evaporating Cloud may also bring attention to Undesirable Effects previously not identified. The Evaporating Clouds for the EHC study are depicted in Fig. 4a and b.

There are a number of important aspects of Fig. 4a that merit attention. First, even if the general objective of optimizing caregiver assignments were not in dispute, optimization more specifically can mean at least two different things. If one wishes to optimize travel time, the *routing* formulation seems appropriate. But if one thinks in terms of capacity, one likely starts thinking of how to balance capacity utilization by applying alternative *scheduling* principles. The critical realization here is that optimizing travel time and leveling capacity are not only different objectives, they are also in conflict with one another. This is where the decision maker has to make the call: Do we focus on travel time or capacity? The answer to this question will then provide the basis for addressing the problem. It is, however, important to note that solving the problem is not merely a matter of reasoning and analysis, it requires the incorporation of prioritization through judgment.

Furthermore, no matter how experienced the decision maker, interventions are always likely to give rise to unintended effects, surprises, and conflicts. Fig. 4b describes one such conflict. Suppose a team of five caregivers needs to complete a total of 45 visits during a shift. Suppose further that a single caregiver can complete up to 15 visits during the shift. Dividing the workload as evenly as possible would obviously constitute a *fair* solution in the eyes of the members of the caregiver team. In contrast, those responsible for *efficiency* would rather assign 15 visits each to three caregivers and release the two remaining caregivers to caregiver teams facing an unexpected capacity shortage. The efficiency and fairness considerations are in direct conflict with one another. From the fairness point of view, the choice of giving three caregivers a full load of assignments and none to the remaining two can create a lot of confusion, even resentment, within the caregiver team. This is an example of how stakeholder interests are not only different but sometimes incommensurate. As an aside, the analysis of resource allocation at the team level specifically prompted the system level description of the eight Undesirable effect as caregivers being "stuck in their teams."

3.4. Step 4: design propositions

Applying the Thinking Process method in the EHC study, we can draw a number of conclusions which can be formalized into what could be labeled a *design proposition* (Denyer et al., 2008) that consists of four actions or interventions:

1. Level demand by offloading non-time-critical visits to off-peak hours;
2. Prioritize level demand over minimized travel;
3. Only activate as many caregivers locally as needed to ensure that the average percentage of touch time to total available time per route remains within managerially appropriate threshold limits; and
4. Maintain excess capacity in a common resource pool consisting of skill group buffers; resupply (and desupply) local units based on actual demand.

The four interventions circumscribe a design proposition or solution we label *Demand-Based Replenishment for Home Care* (see Table 2). The proposition specifies the mechanism by which problem representations link to interventions and outcomes. In Table 2, the design is expressed in terms of the context, the intervention, the mechanisms, and the outcomes using CIMO logic. The design proposition can be described as a combinatorial innovation (Arthur, 2007) of largely *existing* artifacts in a novel combination to address the problem in context. Demand-Based Replenishment of Home Care combines two well-known OM-based artifacts: Goldratt's (1988) Five Focusing Steps and Variable-Demand Inventory Replenishment (Cohen et al., 2006). Specifically, the first two interventions apply the Five Focusing Steps and specify how planning should be based on the constrained resource. The last two, in turn, specify the design of a buffer that pools temporary excess capacity that can be made available to meet demand.

The four proposed interventions are outcomes of the Thinking Process analysis. The first two should be self-explanatory by now; the

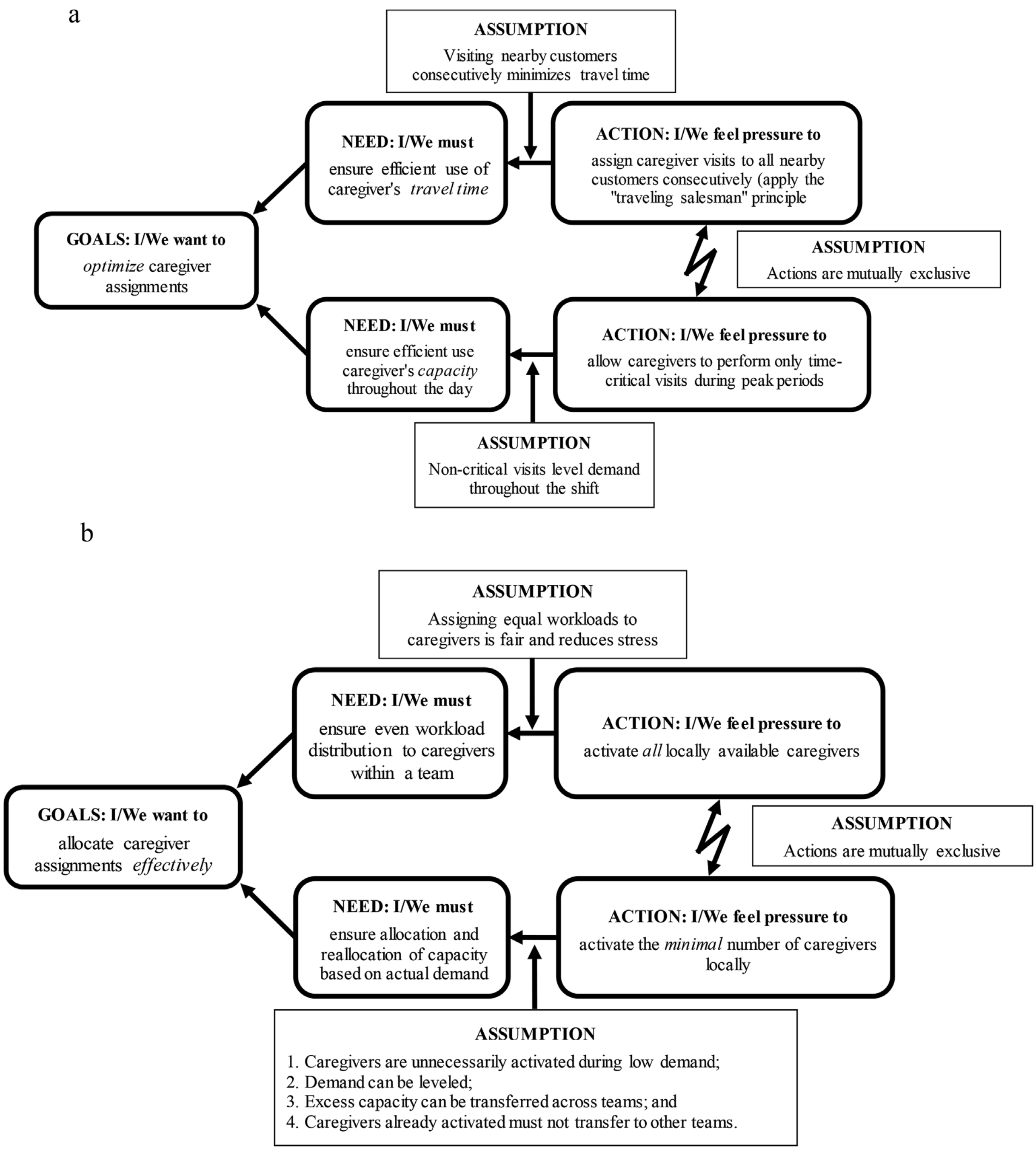

Fig. 4. a. The Conflict Resolution Diagram ("The Evaporating Cloud") for Interventions 1 and 2.
b. The Conflict Resolution Diagram ("The Evaporating Cloud") for Interventions 3 and 4.

latter two require some elaboration. The idea in the third and fourth interventions is, somewhat counter-intuitively, that the planning system should seek to divide workload evenly within the team, but *only if* the available caregiver capacity matches the daily demand. Upon observing excess capacity within a team for the shift, the planning system should free one or more team members to other teams that might have more demand than capacity for the specific work shift. If capacity is planned and allocated at the team level and all team members are assigned visits even when team capacity exceeds demand, productivity suffers: some teams will have excess capacity (which is wasted), and those with a capacity shortage must hire temporary caregivers (which is expensive) or shorten the length of the visits (which reduces quality of care and increases employee stress). Use of temporary caregivers constitutes a further disturbance: temporary workers tend to be less experienced and require extra instructions and ad hoc training, which is performed by regular caregivers. This reduces the regulars' touch time and leads to increased stress and absenteeism, which only makes the problem worse.

Taken together, the design propositions contribute to the academic literature on field tested solutions to improve the delivery of home care. For instance, the solution contributes to the resource allocation aspect of home care (Duque et al., 2015; Eveborn et al., 2006, 2009) by proposing a way to dynamically allocate caregivers *across* teams based on demand. In contrast with extant solutions (Eveborn et al., 2006, 2009), our solution does not start at the assumption that all caregivers should be employed at all times. Similarly, existing solutions tend to ignore the challenges posed by variable demand and excess capacity. Our suggestion is to move any free caregiver capacity to a common resource

Table 2
Demand-based replenishment for home care: A combinatorial innovation.

	Artifact 1: Five Focusing Steps (Theory of Constraints)	Artifact 2: Variable-Demand Inventory Replenishment	Combinatorial innovation: Demand-Based Replenishment of Home Care
Context	Satisfying geographically dispersed and diverse customer needs, some of which are time critical. The operations has a high fixed cost, and chasing demand is infeasible. The peak hour constitutes the central system constraint, which governs the need for labor at the caregiver team level.	How can inventory be managed to effectively respond to variable demand?	Operations management in the home care environment. How should caregiver resources be allocated in a field care setting where both caregiver skills and customer needs are diverse, and some visits are time critical while others are not?
Intervention	Interventions 1 and 2, at the abstract level: develop a schedule that reduces peak time demand and subordinate all scheduling to time-critical peak time demand.	Interventions 3 and 4, at the abstract level: create a common inventory buffer for a large number of demand facing units to reduce the overall need for buffers; replenish demand-facing units from the common buffer according to demand.	The four interventions together, contextualized into the home care empirical setting.
Mechanism	Leveling demand means fewer workers are needed, and they can be utilized more efficiently throughout their work shifts	Buffering excess capacity at the system (not team) level is more effective in tackling variable demand	Focus on time-critical visits leads to more effective team capacity management
Outcome	Improved worker productivity	Reduced need for buffers without sacrificing service levels	Improved touch time

pool. Both demand peaks and capacity shortages are frequent enough in home care to merit attention. For instance, a customer's health may deteriorate rapidly and caregivers are faced with unscheduled additional tasks, such as scheduling urgent medical appointments; bathing a customer returning from hospital with a broken arm requires extra time; examples abound. Of course, any delays with one customer will propagate to subsequent appointments. This is where the common resource pool with stand-by caregivers becomes useful. Reserving extra capacity at the team level would be comparatively inefficient. The basic idea, of course, is nothing new. Various solutions to manage asset deployment to meet variable demand are well known (Cohen et al., 2006). We have simply applied the solution in the home care context.

3.5. Step 5: anticipating and evaluating consequences

Dunbar and Starbuck (2006) highlight the dual learning task of the designer as not just learning *to design* but also learning *from designing*. As for the latter, they write: "Because designers nearly always misunderstand to some degree, they should view their efforts as experiments that might not turn out as predicted, and they should pay careful attention to the outcomes of these experiments" (Dunbar and Starbuck, 2006: 176). Our experience of implementing the four interventions sheds light on the importance of understanding the trial-and-error nature of design research.

Our implementation of the improved design started with just the first two interventions, that is, we first sough to level demand and prioritize it over minimizing travel time. That the third and the fourth interventions would be needed was not known to us when we initiated implementation. At this stage, EHC management was cooperative and provided the organizational support to implement the first two interventions. Upon implementation, however, we realized that in order for the first two interventions to be effective, we ultimately needed to design other interventions that would address caregiver allocation. For example, it became clear that individual caregivers could no longer be permanently assigned to their respective teams. Instead, the planning system would have to transfer caregiver resources from overstaffed to understaffed teams, as late as *at the start of a work shift*. That caregiver teams consisted of dedicated team members had not been viewed as a problem. But now that the new system objective was to level demand, the notion of being “dedicated to a team” metamorphosed into being “stuck in a team,” unearthing the eighth Undesirable Effect. This effectively shows how completing the list of Undesirable Effects before attempting to change the system would limit our ability to solve the practical problem. This is why implementation of proposed interventions and iterative development of the problem framing and solution design are such a crucial part of design research.

Unfortunately, adding the third and fourth interventions was too much for EHC management, and they decided to terminate the redesign effort. The first two interventions would have been fine, but the idea of implementing a caregiver allocation system that would eliminate dedicated teams was considered an excessive disturbance to the system. According to EHC management, a full-blown redesign would be too radical as it would result in a major overhaul of how caregivers are assigned to their tasks. Another aspect that made EHC management wary of changing their management and planning system was the expectation of a rapid increase in demand for home care on the horizon. Understandably, management felt more comfortable tackling the challenge using the familiar and stable system, no matter how incomplete.

The implementation obstacles are an important reminder that design scientists never work in a technological vacuum: all interventions take place in organizational settings, where technology is just one of the relevant issues. Managers are understandably reluctant to have entire operational systems subjected to manipulation and experimentation when the outcome is uncertain. In some circumstances, such experimentation may in fact be illegal.

4. Outcomes, challenges, and limitations

The first implementation of EHC's home care system in 2009–2011 resulted in early termination. But the problems and the symptoms did not disappear, in fact, they got worse: the demand for home care continued to rise while caregiver resources remained essentially the same. After seeking other ways of solving the problem, EHC management approached us again in 2013. By that time we had implemented the four interventions of the solution design in *Porvoo*, a smaller coastal town in Finland with a population of 50 000 people. In the following, we discuss the outcomes of the second EHC implementation, with some of the results we observed in Porvoo for comparison.

4.1. The second implementation of EHC

In 2013, EHC management was willing to implement all four interventions. One reason was that they understood that even though implementing all four interventions constituted a major overhaul of the system, a partial implementation would ultimately not adequately address the overarching problem. It was at this point that we also uncovered a technical constraint, which had made EHC management more hesitant to engage in full implementation previously. At the time of the first implementation, EHC did not have an effective scheduling system, which meant that planning for demand-based replenishment would have been highly labor intensive. By the time of the second implementation, EHC was in the process of implementing a scheduling

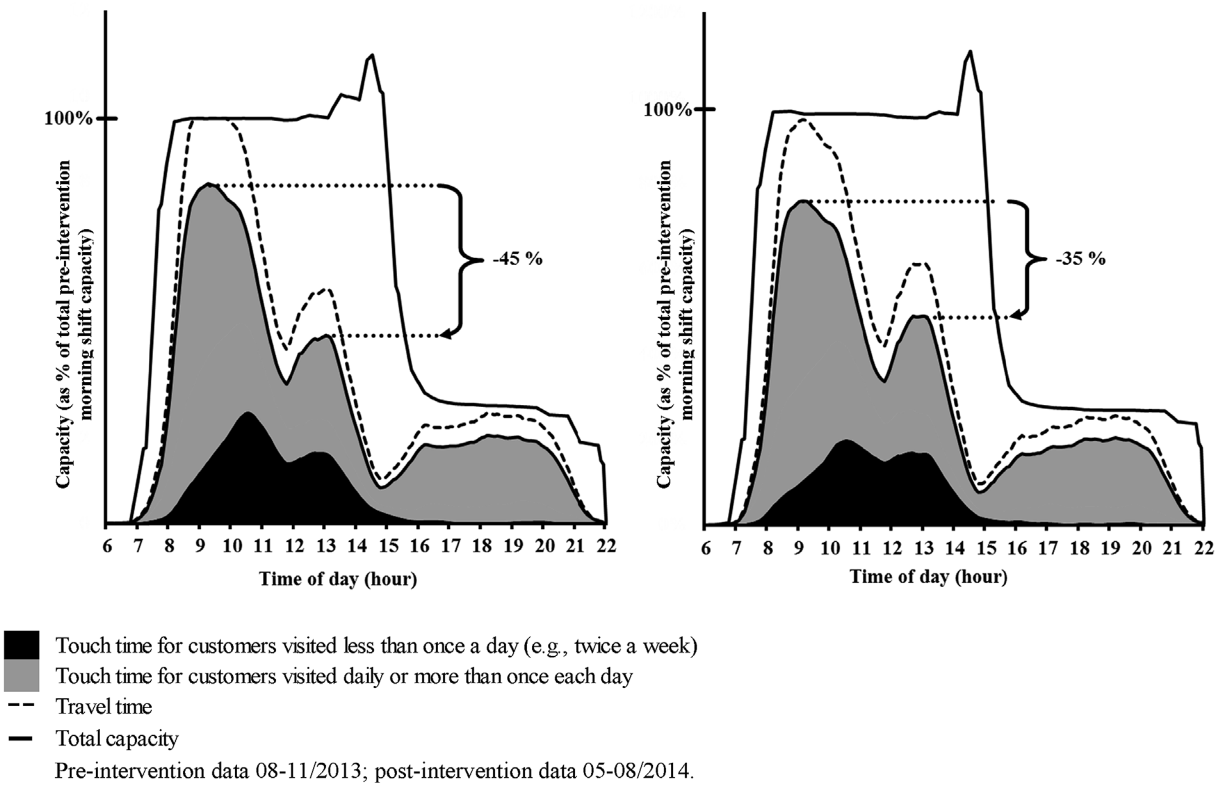

Fig. 5. Pre- and Post-Intervention Caregiver Allocation at EHC (Espoo).

and optimization software similar to the one described by Eveborn et al. (2006). This software enabled the planner to quickly get an overview of caregiver routes over a wide geographic area, greatly facilitating management's confidence to fully implement demand-based replenishment. As a result, replenishment of caregivers shift by shift would be more effective, and more stakeholder viewpoints could be incorporated. For example, more effective scheduling not only enabled the balancing of caregiver workload across shifts but also caregivers immediately saw how this helped them in their daily work. Final scheduling of assignments could be completed at the last minute, without confusion, which meant that planners could feasibly match the real demand for the shift with supply. Due to improved flexibility and responsiveness, caregivers were now able to handle even unexpected assignments without feeling rushed or uncertain. This obviously benefited the customers as well. At the same time, effective scheduling worked toward overall system efficiency. In 2013–2014, all four interventions of the design proposition were implemented.

4.2. Key result 1: leveling capacity utilization

One of the key results of the second EHC implementation is shown in Fig. 5. The objective was to balance the daily caregiver workload, and as the figure shows, this was at least partially successful. Before the intervention, the afternoon capacity peak was 45 percent lower than the morning capacity peak. After the intervention, the difference was 35 percent. This is a substantial improvement. Now, we cannot possibly claim that the effect was entirely due to the intervention: as with all quasi-experiments, no controls are exercised, and we only observe the net before-versus-after effect. At the same time, the intervention was aimed directly at the outcome that was in fact observed: by rethinking how time-critical and non-time-critical visits should be scheduled, the workload could be allocated more evenly during the day.

The corresponding results are shown in Fig. 6 in the case of Porvoo. The difference between the two peaks shrank from 49 percent to 30 percent, an even greater improvement than in Espoo. Implementation in Porvoo in particular shows that before the intervention, non-time-critical visits were indeed unnecessarily scheduled in the morning hours. Both post-implementation graphs show a more even distribution of non-time-critical visits throughout the day. Finally, a significant improvement in the case of Porvoo was also the fact that a roughly equal amount of touch time was provided with nearly 12 percent less caregiver capacity (Fig. 5).

To clarify, we did not have direct data on whether an individual visit was time critical. In order to construct Figs. 5 and 6, we used the number of visits to the same customer per day as a proxy. Specifically, the black areas in Figs. 5 and 6 indicate the total touch time for customers who are visited less than once per day, for example, twice a week. It is reasonable to assume these visits—or at least the vast majority of them—are not time-critical. In contrast, daily visits (or more frequent) are more likely to be time critical, particularly in the morning rush hours. Evaluating the distributions of time-critical and non-time-critical visits in the morning rush hours in particular is important.

4.3. Key result 2: improved productivity

In both Espoo (EHC) and Porvoo, we also observed an improvement in productivity. The effect was particularly evident in Porvoo, so we will focus on its result. The most meaningful productivity metric in this setting is the cost of one hour of care, calculated by dividing the total cost of running the system by total system touch time. This metric gives us the most relevant productivity metric: What is the cost of spending an hour with the customer? The pre-intervention cost in Porvoo was 93 euros and the post-intervention cost 83 euros, a 12-percent improvement. This was mainly driven by a 24-percent improvement in touch time, which rose from 38 percent to 47 percent (the corresponding touch time improvement at EHC was 5 percent, a notably lower but nonetheless a substantial improvement). This improvement was due to two factors. One was that with the new solution design the demand for home care could be met with fewer caregiver resources. When demand peaks are less pronounced, caregiver resources—again, essentially a

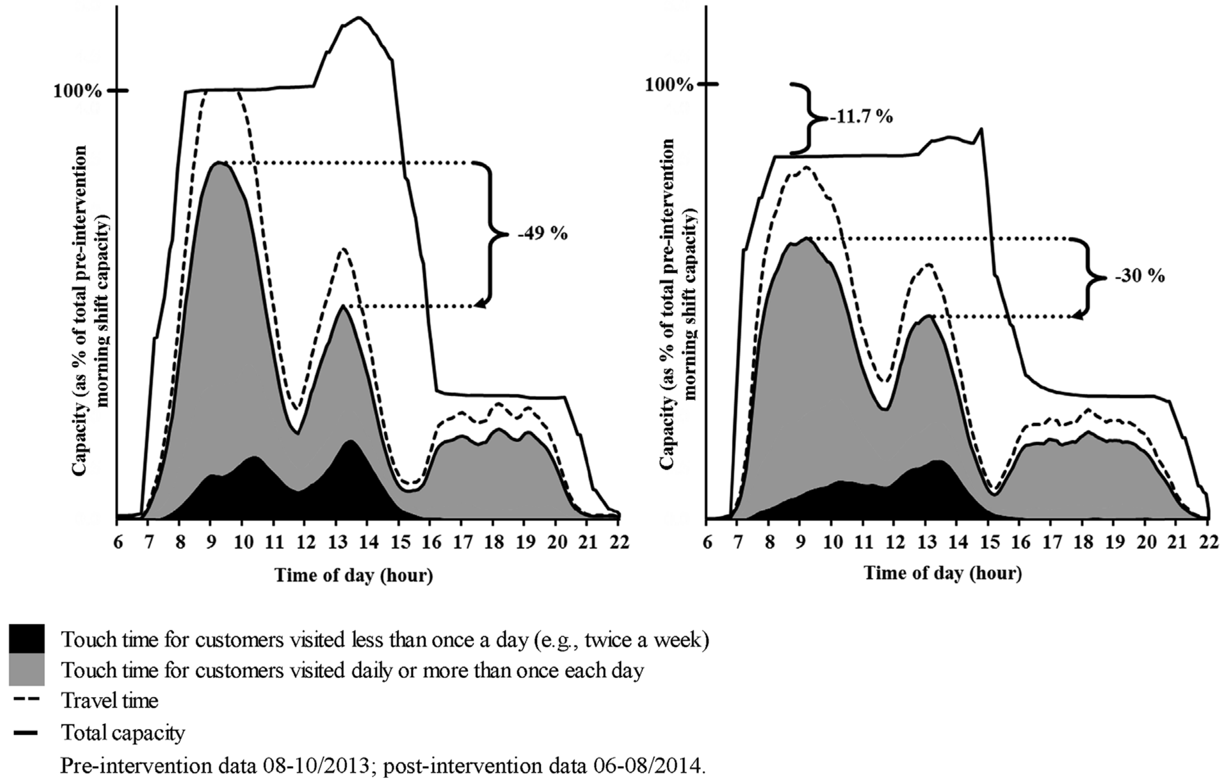

Fig. 6. Pre- and Post-Intervention Caregiver Allocation in Porvoo.

fixed cost—can be used more efficiently. In the post-intervention system, Porvoo was able to produce the same number of customer touch time hours as pre-intervention, with 12 percent less capacity. This immediately resulted in commensurate savings in the total cost of running the system. The other factor was that because of more efficient caregiver allocation, the need to hire temporary caregivers was reduced by about a third in post-intervention. This both decreases the numerator of the productivity equation (temporary caregivers constitute an additional cost to the system) and increases the denominator (fewer temporary caregivers means higher touch time for regulars). Again, the entire 12-percent productivity improvement can certainly not be attributed solely to the intervention, but we are confident that the order of magnitude of the impact of the new system is more likely ten percent than one percent. This is an improvement of unambiguous practical relevance.

4.4. Limitations and boundary conditions of the proposed design

The solution design is structurally equivalent to an inventory replenishment system where the buffer is moved from customer-facing units to a common centralized inventory. This enables an improved service level without the need to add resources. The *generative mechanism* of the design is that actual demand pulls resources from a resource buffer, as opposed to trying to position resources on the basis of forecasted demand within teams. Maintaining resource buffers at the team level will frequently result in a mismatch between demand and supply. In contrast, the common resource pool—the "centralized inventory"—works efficiently in that it rarely faces demand conditions that cannot be met. This describes *the economic rationality* of the home care system.

There are a number of further observations from Figs. 5 and 6 that merit attention specifically because they run counter to the norms of economic rationality. The most obvious is the fact that designers of the system clearly do not attempt to chase demand with supply, in fact, the highest capacity occurs between 2 p.m. and 3 p.m. when demand is *at its lowest*. In order to understand why this happens, we must understand the institutional context in which the system operates. Specifically, there are many legal and contractual boundary conditions that regulate how much work caregivers can perform and when, which in turn affects productivity. For example, the morning shift is 7 a.m. to 3 p.m. and the evening shift 2 p.m.–10 p.m. The one-hour overlap from 2 p.m. and 3 p.m. is simply unavoidable. In the context of the country's labor law and employment contracts, if an employee starts a morning shift at 7 a.m. and has completed all the assignments by noon, sending the employee home without pay for the remaining two hours of the shift would constitute a breach of contract. The employment contract stipulates that the morning shift ends at 3 p.m., whether there is work to be performed or not. Therefore, the peak in capacity in the early afternoon is simply an artifact of the institutional environment; it is certainly not economically rational, but it is understandable given the context. In the case of Porvoo, however, the decision makers did make note of the overlap and were able to partially eliminate it post-intervention. But even after partial elimination, the capacity available in the early afternoon hours still dwarfed demand. Another boundary condition we observed was that home care units tend to minimize capacity in the evenings and the weekends. A simple and understandable reason for this is the fact that most caregivers prefer not to work in the evenings or the weekends.

These are important reminders of how the institutional environment shapes the design and limits the performance of an operational system. Not everything that is economically sensible and desirable is possible to implement in a setting embedded in an institutional environment of rules and regulations. In short, *economic rationality* is sought in an environment ultimately governed by *normative rationality*. In contrast with the economic variant, normative rationality "refers to choices induced by historical precedent and social justification" (Oliver, 1997: 701). Ignoring the institutional environment and the restrictions that contracts, policy, and legislation impose on the system will not only marginalize the interests of some of the stakeholder groups, but it also leads to fundamentally distorted and overly optimistic conclusions of how efficient the system can be. In this case, it is clear that aspects of the institutional environment restrict system performance long before the system has reached the efficient frontier, as defined by assets or technology (Hayes et al., 2005; Schmenner and Swink, 1998). But in order to understand system performance under authentic conditions, these *policy frontiers* that limit system performance must be understood and incorporated into the analysis. More generally, operational systems embedded in highly institutionalized environments are fundamentally different from operational systems in environments where technological and efficiency considerations can be privileged without significant institutional constraints. In the case of the home care system in particular, efficiency considerations can never trump system legitimacy. If the home care system could be fully based on the norms of economic rationality, Figs. 5 and 6 would look drastically different.

5. Discussion and implications

Through our design science effort, we have helped EHC develop a home care system that is more productive in the economic sense. Since the implementation in Espoo and Porvoo, some of the authors of this manuscript have been asked to implement similar solutions in other cities around the country. Our estimate is that our solutions, or some variant of them, are now applied in at least 20 percent of the home care systems operating in Finland. This indicates significant empirical generalizability, at least in the home care setting. Whether the solution generalizes to other settings would require an explicit attempt to implement it in new contexts.

In tackling the home care problem, there are insights that extend beyond the particular empirical context and the practical problem of resource allocation in home care. In this discussion section, we focus on the broader implications.

5.1. Knowledge creation through engagement and design

It is well established in the design science research literature that the role of researcher extends beyond generating knowledge *for* practice to generating knowledge *with* practice (Van de Ven and Johnson, 2006). In our iterative research process, interactions with EHC had a fundamental impact not only on how the problem was framed, which stakeholder groups were considered relevant, and how implementation was affected and facilitated (e.g., Lawler et al., 1985), but also to how the scholarly contribution ultimately emerged (e.g., Daft, 1984). Most notably, the iterative process of framing and design that led to proposing the third and fourth interventions, the unearthing of the eighth Undesirable Effect, and finally, the formulation of the Demand-Based Replenishment of resources design. Without extensive engagement with the practitioner, these insights would not have been uncovered.

The role of the researcher in this study was clearly more than that of a management consultant engaging in solving a client's problem. Our research with EHC indeed constituted a management engineering effort (Corbett and Van Wassenhove, 1993) aimed at engaging all relevant stakeholders to jointly define, frame, and then attempt to solve an ill-defined problem. This is not what management consultants do. The question here is not about how knowledge is transferred, it is more fundamentally about how knowledge is produced, and for what purpose. From this point of view, management research efforts such as ours can indeed be seen "as equivalent to engineering (in the physical sciences) or medicine and agriculture (in the biological sciences)" (Van de Ven and Johnson, 2006: 808). To the extent this is the aim of management research, we must engage with practice, not merely observe it.

The best example of how engagement with practice led to insight is the emergence of the stakeholder perspective. This was something we had neither incorporated nor considered at the outset, rather, it emerged from our recurring conversations with EHC managers and caregivers. These conversations led us to the important preliminary conclusion that the home care system does not have unambiguous objectives, that every objective represents merely a point of view. Privileging a specific point of view would immediately jeopardize the chances of solving the practical problem, which must be addressed *in its entirety*. Amabile et al. (2001) wrote about how engaging with practitioners in the knowledge production process—not merely after the fact— helps researchers critically evaluate their own assumptions and motives as they produce knowledge. The stakeholder perspective to home care was something that arose specifically from such critical evaluation. The practitioner had an essential role in this evaluation.

5.2. Insights into the CIMO logic

Our study has important implications for how the CIMO logic applies to OM research in general and design OM research in particular. As to the former, even though CIMO logic is developed in the context of design research (Denyer et al., 2008), just about any empirical OM study is a special, however incomplete, case of its application. Consider a survey research study that looks at the effect of implementing just-in-time (JIT) manufacturing to inventory costs in automobile assembly: implementation of the JIT system constitutes the intervention (I); inventory cost is the outcome (O); automobile assembly is the context (C), and the mechanism (M) is the way in which parts of the JIT system, such as use of the *Kanban* system guides material flow. All the elements of CIMO are present. One could take just about any other example from empirical OM and conduct a similar analysis. Our design research project offers four different insights into this.

First, in most practice-performance studies in OM, the relationship between the intervention and the mechanisms is taken as straightforward: in implementing JIT, one chooses the tools and the requisite mechanisms that lead to the desired outcomes are triggered in consequence. Our study unearths two significant complicating factors. One is that every intervention has undesirable effects, meaning that some mechanisms are unpredictable and emergent. The second is that implementation does not necessarily trigger the desired mechanisms, or triggers just a subset of them. Therefore, the intended and the actual implementation of an intervention in an operational system may be two entirely different things. Operational systems never react to interventions exactly how we had anticipated.

Second, our study highlights how sensitive implementation and mechanisms are to the context. Not only does the context pervade the entire design effort, but also discovering what is relevant about the context requires considerable empirical effort (Busse et al., 2017). Further, much of the action is in the details, which became evident as we realized that the assumption that Espoo and Porvoo would be identical in terms of context was unfounded. Instead, what we found was that even small differences in the institutional environment can have a significant impact on the feasibility of an intervention. This ultimately then manifests in the fact that the same intervention does not necessarily trigger the same mechanisms when the contexts are different. Solution designs are incredibly sensitive to small perturbations in the environment. Further, some of the relevant key institutions can be organization specific, and therefore, very local. The challenge is in many ways analogous to exploring and specifying the boundary conditions of a theory (Busse et al., 2017; Whetten, 1989). In design research, many of these boundary conditions link to the empirical context.

Third, everything is in flux. Changing problem framing renders some characteristics of the context relevant and others irrelevant. Observing unintended consequences in particular prompts the design researcher to modify the intervention. Again, the best example of this in our research was the fact that we did not realize the need for the third and fourth interventions until we tried to implement the first two. What was at the outset simply a feature of the system ("caregivers *are assigned to* dedicated teams") metamorphosed into a challenge ("caregivers *are stuck in* their teams") once the problem was framed as one of leveling demand. What puzzles us is that we cannot identify a single article in the research literature on home care systems that has observed and analyzed—even recognized—unintended consequences or undesirable effects. Given how prevalent they were in our study and how fundamentally they affected the end result, we must ask: Is this omission a material oversight? To be sure, we would have greatly benefited from reading about unintended consequences of past interventions before we embarked on our research project. Observing something one did not expect is always a learning opportunity.

Fourth, changes in problem framing also change the relevant outcome. Here, JIT actually offers a fitting illustration. The basic tenet in JIT is not minimization *of inventories* but minimization *of waste*. Whether inventories are construed as a form of waste depends on how the problem is framed in the given context. It is certainly possible to frame the problem of minimizing waste as an inventory management problem, but there are other options as well, the best-known probably being the idea on focusing on identifying and eliminating non-value-added steps from the process (Liker, 2004). Focusing on value added may have nothing to do with inventories. More fundamentally, the concept of inventory is not even relevant in some contexts, such as many professional service systems. Minimization of inventories must never be taken as a given, *a priori* objective in designing JIT-based operational systems. Bringing this to the context of home care, majority of the research on home care systems has indeed taken a specific objective as a given, as an *a priori* objective. Doing this sets, however, a very strong boundary condition for the applicability of any solution in an authentic setting. In authentic problem-solving situations, objectives are likely the outcome of a negotiation between different coalitions (Cyert and March, 1992), which transforms strategic and operational decisions into essentially political decisions (e.g., Dean and Sharfman, 1993; Eisenhardt and Bourgeois, 1988). This is a fact few OM researchers acknowledge, let alone incorporate into their inquiry. It is of course easy to agree that caregiver assignments must *be optimized*. But as soon as one starts analyzing the operational implications of what optimization actually entails, one finds that there are many ways to think about optimality. In our study, caregivers thought of optimality in terms of fair and equal workload. In contrast, managers focused on optimality in terms of overall resource allocation. These two views of optimality are incommensurate.

Fig. 7 summarizes our research process and the tools we used using the CIMO logic as the guiding framework. As we already mentioned, CIMO is only an acronym that neither describes nor prescribes the order in which the various elements are considered. Indeed, we found that the sequence C-M-I-O provides a better description of our research process. Of course, the process is also iterative in that observing unintended outcomes of interventions must lead to re-evaluation of the context. This aside, that consideration of mechanisms precedes intervention highlights the important fact that the emphasis in the beginning was to understand how the system operated, what the Undesirable Effects were and what was causing them. This understanding must be developed prior to designing the interventions that resolve conflicts in a way that considers these Undesirable Effects in the solution design phase. Simply put, understanding the system is logically prior to trying to change it.

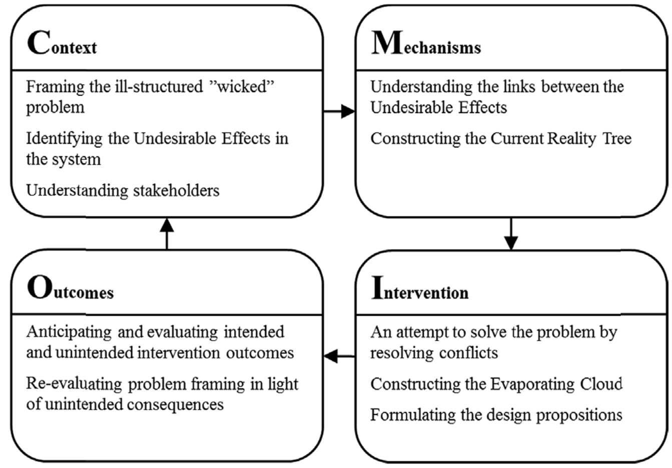

Fig. 7. CIMO logic in the homecare context.

5.3. In what sense does the designer solve the ill-defined problem?

Daft (1984: 12) noted that "[g]ood research takes a problem that is not clear, is in dispute or out of focus, and brings it into resolution." He further suggested that the outcome of a research process is some notion of certainty. In design research, the issue is more complicated and the notion of resolution in particular requires qualification. Framing the ill-defined problem in a certain way can certainly bring focus to the inquiry, but it would be misguided to assume that this converts an ill-defined problem into a well-defined one. Throughout the design research effort, including the end, design researchers must respect their ignorance (Dunbar and Starbuck, 2006). In retrospect, we are convinced that our intervention had a demonstrable and a practically significant impact on system productivity. But we are equally certain that even though we have brought more focus to the home care problem, the fundamental problem itself remains ill-defined. Those interested in further improving the system must adopt a similar design research approach, instead of handing the problem over to a "General Problem Solver" (Simon, 1973: 183) to seek improvements through an algorithmic approach.

We have come to the conclusion that design research, at least this initiative, does not solve problems so much as it addresses particular design problems using *an evolutionary lens* (Whyte, 2007). Designers with an evolutionary mindset recognize the importance of understanding that design is a trial-and-error process. They understand the perpetual co-evolution of interventions and problem context. There are no stopping rules (Buchanan, 1992). They also readily understand that all solution designs will result in at least some unintended consequences, unearthing potentially undesirable features of the solution design, which in turn necessitates further adaptation (Holland, 1995). There is little about this process that generalizes into a complete solution. "Every *wicked problem* is unique" (Buchanan, 1992: 16).

6. Conclusion

In our research, we helped two cities in Finland improve their home care system for senior citizens. The solution, jointly developed with the practitioner, combines Theory of Constraints with principles of variable-demand inventory replenishment, in an attempt to allocate caregiver resources in a more effective manner. The applicability of the particular solution design is limited to contexts where the current solution design, caregiver supply and customer demand present problems similar to the Undesirable Effects observed at EHC. It is probably the case that in the U.S., many collective labor agreements do not set limitations that are as strict as they are in Finland. For example, if caregivers are not salaried employees but either hourly workers or independent freelancers, capacity management becomes much easier even at the team level. Our solution is developed in a context in which caregivers are essentially a fixed cost and hire-and-fire practices are infeasible.

In addition to being able to contribute to the solving of a practical problem, there are a number of more general lessons. Most importantly, we have observed that in real life, there is no such thing as an operational problem, all problems are ultimately organizational (cf. van Aken et al., 2016). Consequently, all attempts at trying to improve the productivity of an operational system must incorporate the institutional environment, organizational politics, and only partially overlapping preferences of different stakeholder groups. We have also learned that it takes an explicit attempt to change a system that brings these aspects to surface. Those who simply observe operational systems have the luxury of being able to abstract out those aspects of the system that are out of scope of their intellectual inquiry. When the knowledge interest is theoretical, abstraction is possible, even encouraged. But when the knowledge interest is practical, we must accept the premise that it is not our theory but the empirical reality that ultimately defines what is relevant.

Statement of conflict of interest

The research idea for this paper was conceived when the lead author, Dr. Johan Groop, was a doctoral candidate at Aalto University. The theoretical ideas presented are from Dr. Groop's doctoral dissertation. The primary data used in the analyses were collected after Dr. Groop's graduation, at a time when he worked as a researcher and consultant at Finland-based Nordic Healthcare Group, a for-profit management consultancy specialized in planning and developing health and social services, such as the ones examined in this paper. The other authors declare no conflicts of interest.

Acknowledgments

Design science research by definition requires deep collaboration with the practitioner. We are indebted to all the organizations involved in this research, particularly the management and staff of Espoo and Porvoo home care organizations. They were not only sources of data but also had an indispensable role in developing and field testing of the solution. We also thank Mikko Mulari and Pentti Martiskainen for their assistance in data analysis and the rolling out of the demand-driven replenishment model in Espoo and Porvoo. Finally, we thank Dan Guide, Joan van Aken, the Design Science Department Associate Editor and reviewers for their insightful and constructive comments and evaluations of the earlier versions of this paper.

References

Amabile, T.M., Pattterson, C., Mueller, J., Wojcik, T., Odomirok, P.W., Marsh, M., Kramer, S.J., 2001. Academic-practitioner collaboration in management research: a case of cross-profession collaboration. Acad. Manag. J. 44, 418–431.
Aristotle. [~ 300 BCE], 1923. In: Ross, W.D. (Ed.), Organon.
Arthur, W.B., 2007. The Nature of Technology: What It Is and How It Evolves. Simon and Schuster, New York.
Begur, S.V., Miller, D.M., Weaver, J.R., 1997. An integrated spatial DSS for scheduling and routing home-health-care nurses. Interfaces 27, 35–48.
Buchanan, R., 1992. Wicked problems in design thinking. Des. Issues 8, 5–21.
Busse, C., Kach, A.P., Wagner, S.M., 2017. Boundary conditions: what they are, how to explore them, and when to consider them. Organ. Res. Methods 17, 574–609.
Churchman, C.W., 1967. Guest editorial: free for all. Manag. Sci. 14, B141–B146.
Cohen, M.A., Agrawal, N., Agrawal, V., 2006. Achieving breakthrough service delivery through dynamic asset deployment strategies. Interfaces 36, 259–271.
Cohen, M.D., March, J.G., Olsen, J.P., 1972. A garbage can model of organizational choice. Adm. Sci. Q. 17, 1–25.
Corbett, C., Van Wassenhove, L.N., 1993. The natural drift: what happened to operations research? Operations Res. 41, 625–640.
Cyert, R.M., March, J.G., 1992. A Behavioral Theory of the Firm, second ed. Prentice-Hall, Englewood Cliffs, CA.
Daft, R.L., 1984. Antecedents of significant and not-so-significant organizational research. In: Bateman, T.S., Ferris, G.R. (Eds.), Method and Analysis in Organizational Research. Prentice-Hall, Reston, VA, pp. 3–14.
Davies, J., Mabin, V.J., Balderstone, S.J., 2005. The theory of constraints: a methodology apart?—a comparison with selected OR/MS methodologies. Omega 33, 506–524.
Dean, J.W., Sharfman, M.P., 1993. Procedural rationality in the strategic decision-making process. J. Manag. Stud. 30, 587–610.
Dearborn, D.C., Simon, H.A., 1958. Selective perception: a note on the departmental identification of the executive. Sociometry 21, 140–144.
Denyer, D., Tranfield, D., van Aken, J.E., 2008. Developing design propositions through research synthesis. Organ. Stud. 29, 393–413.
Dettmer, H.W., 1997. Goldratt's Theory of Constraints: a Systems Approach to Continuous Improvement. ASQC Quality Press, Milwaukee, WI.
Dunbar, R.L.M., Starbuck, W.H., 2006. Learning to design organizations and learning from designing them. Organ. Sci. 17, 171–178.
Duque, P.M., Castro, M., Sörensen, K., Goos, P., 2015. Home care service planning: the case of Landelijke Thuiszorg. Eur. J. Operational Res. 243, 292–301.
Eisenhardt, K.M., Bourgeois III, L.J., 1988. Politics of strategic decision making in high-velocity environments. Acad. Manag. J. 31, 737–770.
Eveborn, P., Flisberg, P., Rönnqvist, M., 2006. Laps Care—an operational system for staff planning of home care. Eur. J. Operational Res. 171, 962–976.
Eveborn, P., Rönnqvist, M., Einarsdóttir, H., Eklund, M., Lidén, K., Almroth, M., 2009. Operations research improves quality and efficiency in home care. Interfaces 39, 18–34.
Freeman, R.E., Harrison, J.S., Wicks, A.C., Parmar, B., de Colle, S., 2010. Stakeholder Theory: the State of the Art. Cambridge University Press, Cambridge.
Gigerenzer, G., 1991. From tools to theories: a heuristic of discovery in cognitive psychology. Psychol. Rev. 98, 254–267.
Goldratt, E.M., 1988. Computerized shop floor scheduling. Int. J. Prod. Res. 26, 443–445.
Goldratt, E.M., 1990. What Is This Thing Called Theory of Constraints and How Should it Be Implemented? North River Press, Croton-on-Hudson, NY.
Goldratt, E.M., 1994. It's Not Luck. North River Press, Great Barrington, MA.
Groop, J., 2012. Theory of Constraints in Field Service: Factors Limiting Productivity in Home Care Operations. Doctoral Dissertation. Aalto University, Department of Industrial Engineering and Management, Espoo, Finland.
Gualandris, J., Klassen, R.D., Vachon, S., Kalchschmidt, M., 2015. Sustainable evaluation and verification in supply chains: aligning and leveraging accountability to stakeholders. J. Operations Manag. 38, 1–13.
Hayes, R.H., Pisano, G.P., Upton, D.M., Wheelwright, S.C., 2005. Operations, Strategy, and Technology: Pursuing the Competitive Edge. Wiley, New York.
Holland, J.H., 1995. Hidden Order: How Adaptation Builds Complexity. Basic Books, New York.
Holmström, J., Ketokivi, M., Hameri, A.-P., 2009. Bridging practice and theory: a design science approach. Decis. Sci. 40, 65–87.
Lawler, E.E., Mohrman, A.M., Mohrman, S.A., Ledford, G.E., Cummings, T.G., 1985. Doing Research that Is Useful for Theory and Practice. Lexington Books, New York.
Liker, J.K., 2004. The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill, New York.
Mingers, J., 2011. Soft OR comes of age–but not everywhere!. Omega 39, 729–741.
Mingers, J., Brocklesby, J., 1997. Multimethodology: towards a framework for mixing methodologies. Omega 25, 489–509.
Morgan, S.L., Winship, C., 2007. Counterfactuals and Causal Inference: Methods and Principles for Social Research. Cambridge University Press, Cambridge.
Oliver, C., 1997. Sustainable competitive advantage: combining institutional and resource-based views. Strategic Manag. J. 18, 697–713.
Osborn, R., Moulds, D., Squires, D., Doty, M.M., Anderson, C., 2014. International survey of older adults finds shortcomings in access, coordination, and patient-centered care. Health Affairs 33, 2247–2255.
Payne, G.T., 2006. Examining configurations and firm performance in a suboptimal equifinality context. Organ. Sci. 17, 756–770.
Sarasvathy, S.D., 2001. Causation and effectuation: toward a theoretical shift from economic inevitability to entrepreneurial contingency. Acad. Manag. Rev. 26, 243–263.
Sarkis, J., Gonzalez-Torre, P., Adenso-Diaz, B., 2010. Stakeholder pressure and the adoption of environmental practices: the mediating effect of training. J. Operations Manag. 28, 163–176.
Schmenner, R.W., Swink, M.L., 1998. On theory in operations management. J. Operations Manag. 17, 97–113.
Simon, H.A., 1973. The structure of ill structured problems. Artif. Intell. 4, 181–201.
Simon, H.A., 1997. Administrative Behavior, fourth ed. Macmillan, New York.
van Aken, J., Chandrasekaran, A., Halman, J., 2016. Conducting and publishing design

science research: Inaugural essay of the design science department of the Journal of Operations Management. J. Operations Manag. 47, 1–8.

van de Ven, A.H., Johnson, P.E., 2006. Knowledge for theory and practice. Acad. Manag. Rev. 31, 802–821.

Watson, K.J., Blackstone, J.H., Gardiner, S.C., 2007. The evolution of a management philosophy: the theory of constraints. J. Operations Manag. 25, 387–402.

Whetten, D.A., 1989. What constitutes a theoretical contribution? Acad. Manag. Rev. 14, 490–495.

Whyte, J., 2007. Evolutionary theories and design practices. Des. Issues 23, 46–54.

Yuan, B., Liu, R., Jiang, Z., 2015. A branch-and-price algorithm for the home health care scheduling and routing problem with stochastic service times and skill requirements. Int. J. Prod. Res. 53, 7450–7464.