

Designing Controls for a Marketplace of Health Care Services: a Case Study

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Abstract:

The health care system in the Netherlands is undergoing restructuring. The once strongly regulated healthcare system with a limited number of care providers is transforming into a marketplace with a wide variety of care providers. We expect that this restructuring will also create new opportunities for electronic business in health care. In this paper we report on ideas of the FRUX project about an electronic marketplace called Social Chart. We want to analyse what are the opportunities of the electronic marketplace Social Chart in the business model of the Dutch health care system. The analysis is done with the e^3 -value/control methodology, which applies business modelling and accounting control theory approaches to the design of network organisations. Our second goal is to investigate the potential use of this methodology for analysis of problems in network business models and for discovering of new business models.

Keywords: value modelling, e^3 -value/control, inter-organisational control mechanisms, electronic marketplace, e-health.

1 Introduction

Currently, there is an ongoing restructuring of the health care system in the Netherlands. The general idea is to shift from a supply-driven towards a demand-driven service provisioning (Ex et.al 2003, MinVWZ 2005). While in the supply-driven system people were able to get a subsidy only for services of a limited number of government contracted providers (e.g. big hospitals), in the restructured system they will be able to get funding for services from a wider range of service providers.

One of the goals of this restructuring is to make the health care services better available to people. This restructuring aims to increase the number of health care providers, and creates opportunities for the entrance of new market players, such

as intermediaries, who offer bundles of health care services from different service providers. Currently many health care providers provide online information about their services, and the patient's choice of these services will be more and more influenced by this type of online information. It is expected that the combination of demand-driven service provisioning and online information dissemination will lead to more electronic marketplaces in the health care industry. In this paper we report on some results of the FRUX project about the so called Social Chart (Droes et.al. 2005). The Social Chart is a web-site that is currently developed to offer online information about care providers in the Netherlands for a specific group of people; namely dementia patients and those people who help these patients. The Social Chart has two main functions: an online care product advice, and quality assessment via an online community review system. The second function was one of the results of the control analysis of the Social Chart presented in this paper. It is expected that the Social Chart will play an important role in facilitating the development of electronic marketplaces for health care services.

The goal of this paper is twofold. Our first goal is to analyse the control problems that arise due to demand-driven service provisioning in the Dutch health care system, and which role the Social Chart can play in the solution of these control problems. We use the e^3 -value/control methodology (Kartseva et.al. 2005) for this analysis. This methodology applies ideas from accounting control theories to the business modelling methodology e^3 -value (Gordijn, Akkermans 2003). Our second goal is to investigate the use of this analysis of control problems in business models for discovering new business opportunities related to solutions of these control problems.

The remainder of the paper is structured as follows. First, in section 2 we explain concepts of the e^3 -value/control methodology. In section 3 we describe and analyse the case in the health care sector. In section 4 we present conclusions.

2 Design of inter-organisational control mechanisms

In our previous work (Kartseva et.al. 2005) we introduced the e^3 -value/control methodology. The e^3 -value/control methodology consists of the e^3 -value/control design framework and the e^3 -value/control ontology. Because the e^3 -value/control methodology is an extension of the e^3 -value methodology (Gordijn, Akkermans 2003), we first shortly explain the e^3 -value methodology.

2.1 e^3 -value

The e^3 -value methodology supports the conceptualisation of a business network by constructing a value model (see Gordijn, Akkermans 2003), representing it graphically in a rigorous and structured way, and performing an economic sensitivity analysis for all organisations involved. In particular, the e^3 -value methodology provides modelling concepts (the e^3 -value ontology) for showing which parties exchange things of *economic* value with whom, and expect *what* in return. The methodology has been validated in a series of case studies including media, news, banking and insurance, electricity power, and telecommunication companies to design value models of network organisation (Gordijn, Akkermans 2003).

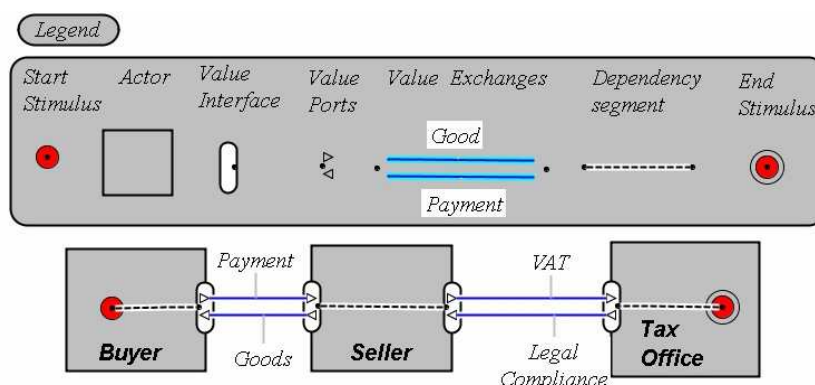


Figure 1. An e^3 -value model of a Purchase with Tax payment.

A value model in Figure 1 represents a buyer obtains goods from a seller and offers money in return. According to the law, the seller is obliged to pay the value-added tax (VAT). To represent this simple value model, e^3 -value utilises such concepts as Actor, Value object, Value exchange etc. A more detailed description of e^3 -value concepts can be found in the Appendix.

2.2 The e^3 -value/control design framework

Based on the control theory (Romney, Steinbart 2003, Starreveld et.al. 2004), in designing control mechanisms it must be considered what could go wrong in the value model. The value model can be in two states: (1) actors act in a way the e^3 -value model prescribes, which further is referred to as an *ideal situation*, or (2) actors violate some prescriptions of the value model, which is referred to as a *sub-*

ideal situation. Therefore, to design control mechanisms, we propose an *e³-value/control design framework*, which consists of the following three steps:

Step 1. Design of the ideal situation within value exchange perspective

Step 2. Control problem analysis, or the analysis of possible sub-ideal situations

Step 3. Design of inter-organisational controls, including *detecting*, *preventing* and *correcting* control problems

In the first step, a normative model is designed. It represents what actually the exchanges between actors should be. For example, this model can represent exchanges which correspond to an applicable legislation. We call this model the **ideal value model**.

Actors may behave sub-ideally. **Intentional sub-ideal behaviour** is fraud and embezzlement of value; it is also often referred as opportunistic behaviour. **Unintentional sub-ideal behaviour** is errors, made by actors, which result in an incorrect execution of value exchanges. In the second step we capture the problems that are caused by sub-ideal behaviour of actors. We call these problems **control problems**. A model, which represents sub-ideal situation, is called the **sub-ideal value model**.

To prevent or detect the sub-ideal behaviour of actors in a network organisation, **inter-organisational controls (IOCs)** are usually implemented. We define IOCs as those measures that limit the risk a party runs in a business transaction due to the possible existence of sub-ideal behaviour by its trading partners (based on Bons et.al. 1998).

The *internal control* theory proposes several control principles for prevention and detection of fraud and errors made by employees in a hierarchical organisation(see Romney, Steinbart 2003, Starreveld et.al. 2004). The controls can be introduced at any level: communication level (e.g. ensuring secure communication lines) or organisational structure level (Bons et.al. 1998). The most important principles related to the organisational structure are the following:

1. **Segregation of duty principle**. No employee should be given too much responsibility. There are four general categories of duties or responsibilities which are examined when segregation of duties are discussed: [authorization](#), [custody](#), [record keeping](#) and reconciliation. In an ideal system, different employees would perform each of these four major duties.
2. **Control activity principle**: Every operational duty (authorisation, custody or record keeping) should have the corresponding control duty (reconciliation), executed by a separate, socially detached actor.

If these principles are not followed, the employees are more likely to make errors or commit fraud. Unlike the internal control theory, the *management control*

theory (Anthony, Govindarjan 2003) is concerned with control problems related to a low performance of employees in an organisation. Because the problems they address are different, they propose different control principles, such as standardisation of processes and data, creation of incentives for employees, etc.

Although the abovementioned principles were defined for employees in hierarchical organisation, they are also valid for an inter-organisational setting. Namely, segregation of duties in an inter-organisational setting means the segregation of duties between actors in a value model (Bons et.al. 1998). IOCs can be designed using the principles described above. In Step 3, we change the ideal value model of Step 1 by adding IOCs. The changed model is called the **control value model**. In the control value model the IOCs prevent or detect sub-ideal behaviour of actors, modelled in Step 2.

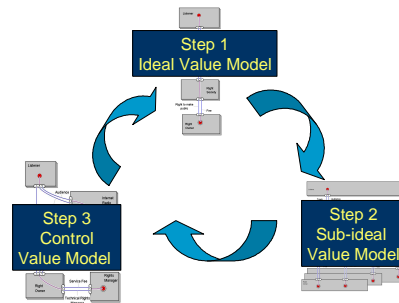


Figure 2. The e^3 -value/control design framework

The three steps can be repeated in **cycles** (see Figure 2). The result of the third step (the control value model) is an ideal model, different from the ideal value model of the first step. The control value model can also be a subject of new control problems. Thus, a new cycle of steps can be performed taking the control value model as an ideal value model in the new cycle. Later we demonstrate this cycle approach in the case study.

2.3 The e^3 -value/control ontology

The e^3 -value methodology defines a constraint called the *Principle of Reciprocity*. It states that an actor can exchange a value object with another actor only in return for at least one another value object; otherwise the actor does not exchange at all. A sub-ideal behaviour, modelled in Step 2, implies that the principle of reciprocity is not fulfilled. For example, in the situation “The buyer delivers goods, the seller does not pay”, only one value object “Goods” is actually exchanged. Modelling such a situation in e^3 -value is not correct, because it requires modelling a non-reciprocal exchange of the value object “Goods”.

To model exchanges for a sub-ideal behaviour, in Kartseva et.al. (2005) we proposed to extend the e^3 -value ontology. First, in e^3 -value/control it is allowed to model non-reciprocal value exchanges. As a result of sub-ideal behaviour, some value exchanges are not reciprocal, or executed differently than in the ideal model (e.g. incorrectly, inaccurately, illegally, etc.). We call these exchanges **sub-ideal value exchanges** and represent them with **dashed lines**. Value objects of the sub-ideal value exchanges are given a different name than the corresponding value objects in the ideal value model (e.g. “No Goods”, “No Payment”, “Damaged Goods”). Second, to model a violating actor, a concept of a **penalty** is introduced. A penalty can be assigned to an actor who executed the sub-ideal behaviour. For more details about the e^3 -value/control see Kartseva et.al. (2005).

3 Case study

The prime objective for health care in the Netherlands is that it should be accessible to all people living in the Netherlands, high quality and affordable. Two categories of health insurance guarantee this objective. The first category is regular medical health insurance for the costs of regular medical care services such as those relating to general practitioners, hospitals and pharmacies. To be insured, a person pays a premium to an insurance company. The second category is insurance for *exceptional care*. The Act on Extraordinary Medical Expenses (in Dutch: AWBZ¹) offers insurance to all Dutch citizens in case of protracted illness, invalidity, learning disability, mental disorders and geriatric diseases. The exceptional health care costs are reimbursed from an AWBZ fund, collected from taxes.

¹ In Dutch: Algemene Wet Bijzondere Ziektekosten (AWBZ)

In this case study we only analyse changes in the business model of *exceptional health care* in the Netherlands. According to the *e³-value/control* design framework, the analysis is unfolded in cycles.

The data were collected from a number of semi-structured interviews with experts from different organisations health care. In total, about five experts were interviewed. In addition, the data were collected from publicly available documents (Ex et.al 2003, Extre et.al. 2004, Okma 2001, PGB 2005, Klaver, Scholten 2002) and government web-sites (www.zorgaanzet.nl, www.minvws.nl, www.pgb.nl, www.cvz.nl, www.overheid.nl). The models were verified by experts.

We start with the past scenario to demonstrate how the Dutch health care system changed from a supply-driven to a demand-driven system. In the future scenario we demonstrate where opportunities for new business models of electronic marketplace are created.

3.1 Cycle 1: The Exceptional Care System

In the first cycle in Step 1 we model the scenario of the exceptional care in the past. In Step 2 we analyse control problems in this scenario and in Step 3 we model control mechanisms.

3.1.1 Step 1: The Past Scenario in Health Care

In order to obtain the AWBZ funding a patient must receive an assessment from an organisation called Regional Needs Assessment Body² (RIOs). The RIO investigates, based on a diagnosis from a specialist or general practitioner, if the patient qualifies for the AWBZ funding, and, if so, sends the patient a needs assessment letter. Until 2003 the needs assessment letter had two functions. First, it advised the patient what services he needs, and second, it gave the patient a legal right to get funding for these services from the AWBZ fund. After the needs assessment letter is received, the patient applies to a Care Administration Office (CAO), whose role is to connect the patient with a care provider. The payment to care providers is also done by the CAO. As well as the RIO, the CAO receives money from the Ministry of Health, Welfare and Sport (from the AWBZ fund). In addition, the patient also pays the care provider a personal contribution, whose amount is regulated by law.

Figure 3 represents an *e³-value* model of the described scenario. The scenario starts with the patient, who needs exceptional care. The patient receives “Product” from care providers. The patient gives the RIO a proof of sickness (“Diagnosis proof”). In return, the RIO gives the needs assessment letter, modelled with two value exchanges: “Product match” and “Right for Product”. The exchanges of the

² In Dutch: regionaal indicatieorgaan (RIO)

patient with the RIO and the care provider are connected with the AND-fork, which means that the patient cannot get “Product” without the needs assessment letter (“Product match” and “Right for Product”). The patients exchange the “Right for Product” with the CAO via the same interface as they exchange “Product” with the care providers. This models that the patient can get “Product” from the care provider only if the CAO confirms the needs assessment letter.

In the exchange between patient and the ministry we model that the responsibility for the quality of health care lies with the government. The patients pay taxes, which are then used for the AWBZ funding. In return, the ministry has to deliver quality healthcare.

The AWBZ fund is distributed in the following way. The RIO gets a fraction of AWBZ funding in return for the “Needs assessment”, a service, described above, executed by the RIO on behalf of the ministry. Another fraction of the AWBZ fund is transferred to the CAO, in exchange for “Matching patient and care provider”.

The CAO pays to the care providers. Until 2003, the system was *supply-driven*. The care providers were paid not based on the products they deliver, but based on the products they offer. The exchange of “Budget” and “Available products” between care providers and the CAO lies on the dependency path that starts with a new start stimulus at the care provider. There is no dependency path between the payment to the care provider (“Budget”) and services the care provider actually delivers (“Product”). In addition, the care provider is also paid by the patient (“Personal Contribution”).

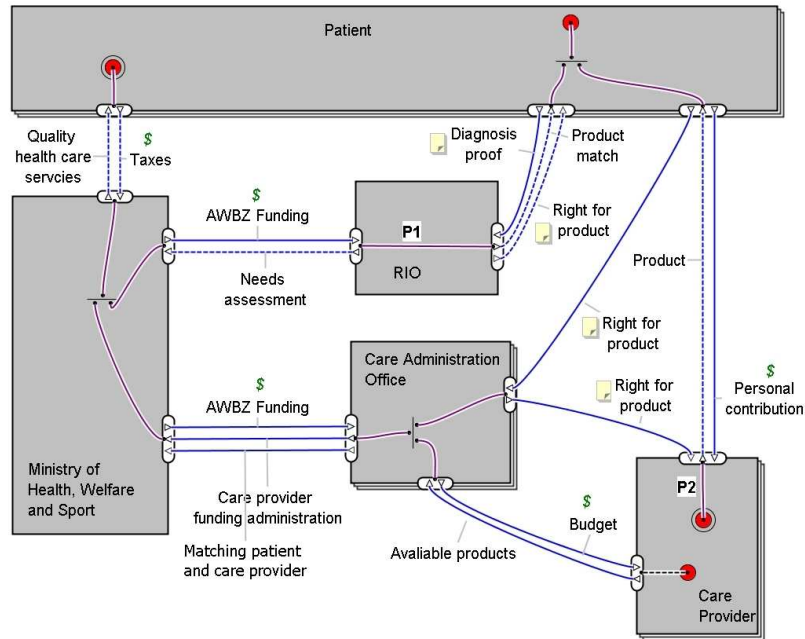


Figure 3. Supply-driven care. Control problems: inadequate needs assessment and no quality control of care providers

3.1.2 Step 2: Problems in the Exceptional Care System

The scenario of Step 1 contains several control problems. In this step we model them using e^3 -value/control. The control problems are modelled in Figure 3 with dashed sub-ideal value exchanges.

Control problem 1: Inadequate needs assessment by the RIO

Description: The first problem concerns the RIO. The RIO is responsible for matching products and the patient's needs ("Product match"), and for giving the patient the right to be paid for these products ("Right for product"). The problem was that the RIO tended to give the needs assessment letter not based on real needs of the patient, but based on the available products. The needs assessment phase was performed not sufficiently good by the RIO. In addition, it was also possible that the RIO could assign to a patient more available products or products of a favoured care providers. As came out of interviews with experts, this situation led to multiple cases of inadequate needs assessment: patients from different regions were given different products for the same diagnosis. From the control

theory perspective, the problem occurred because of inadequate segregation of duties. The RIO was given too much responsibility by doing both needs assessment and giving the rights for products.

Modelling: This problem is modelled in Figure 3 by marking the value exchanges “Product match”, “Right for product” and “Needs assessment” with dashed lines. A penalty P1 is assigned to the RIO to mark this actor as the responsible for the sub-ideal exchanges.

Control problem 2: Low quality of products by care providers

Description: The quality of health care is of major importance. In Figure 3, we do not have an actor who would ensure the quality of care products. This violates the control activity principle (see section 2). There is no actor, who controls quality of products. As a result, provisioning of products of lower quality could remain undetected.

Modelling: In the model in Figure 3 the exchange of “Product” between the patients and care providers is marked as sub-ideal, and a penalty P2 is assigned to the care provider.

The control problems 1 and 2 could result in a low quality of healthcare, and in inadequate taxes. Therefore, the exchanges “Taxes” and “Quality of health care” between the patients and the ministry are also marked with a dashed line.

3.1.3 Step 3: The Exceptional Care System until Recently

In Figure 4 we model how the exceptional care system was modified by the Dutch government on April 1, 2003, and how it affected the control problems.

Control mechanism 1: Splitting the “Product Match” and “Needs Assessment” Value Exchanges.

Description: To solve the first problem, the government separated the functions of the RIO. Instead of the RIO, a Care Indication Determination Centre (CIZ) was created. The needs assessment executed by the CIZ has to be independent, the mission statement of the CIZ³ states. Unlike the RIO, the CIZ is only responsible for needs assessment, but is not legally responsible for assigning a patient with a specific product.

³ “Het is onze missie om op grond van wettelijke bepalingen de indicatiestellingen voor de Algemene Wet Bijzondere Ziektekosten eenduidig, onafhankelijk en integraal uit te voeren voor onze cliënten.” From web-site of CIZ (www.ciz.nl)

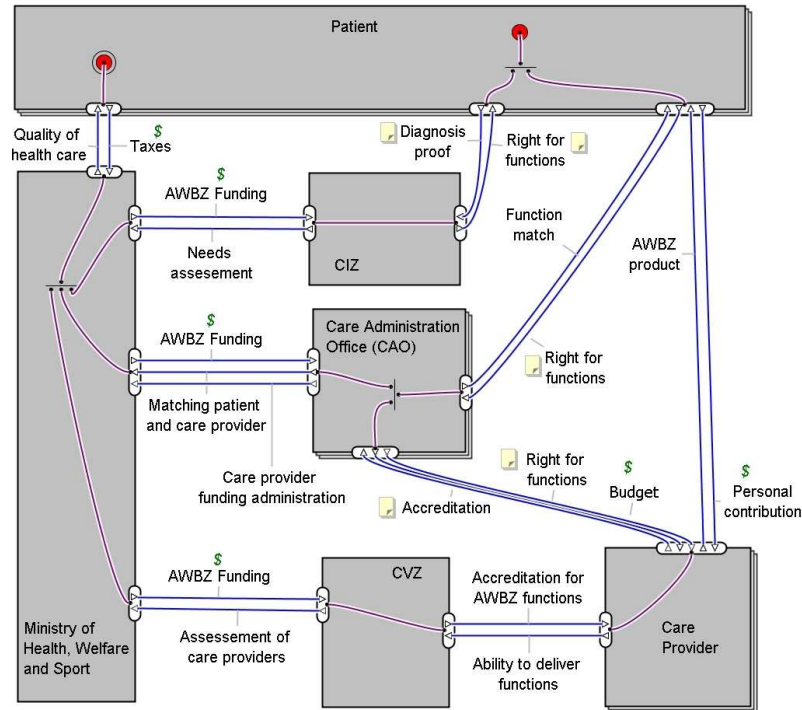


Figure 4. Demand-driven care. Controls: splitting value exchanges of the RIO, introduction of functions and the CVZ

In addition, the government created a function-based needs assessment. Seven types of care products and services (called functions) were defined. Each function has a different price, depending on the degree of seriousness of the patient's disease. The CIZ provides a needs assessment letter, which indicates functions the patient has a right for. Based on the needs assessment, the CAO is responsible for providing the patient a care provider who can implement the functions in the needs assessment letter. The introduction of the functions is a control mechanism, called **standardisation**. It implements similar ideas as standard costing from management control (Anthony, Govindarjan 2003). Having this standardisation allows providing a needs assessment, based on common standards (functions), and not related to available products. This makes the needs assessment objective.

Modelling: In Figure 4 the "Function match" is provided to the patients by the CAO (unlike "Product match" by the RIO in Figure 3). The CIZ does not provide the "Right for products" to the patients, as in Figure 3, but the "Right for functions".

Control mechanism 2: Assessment of Care Providers

Description: To solve the second control problem, the government introduced a requirement that the CAO can only make a contract with a care provider, if the care provider has an accreditation from the Health Care Insurance Board (CVZ). A care provider has to prove to the CVZ that he has enough means and expertise to deliver AWBZ-related products.

In addition, the care provider is now paid depending on the products he provides. The system is *demand-driven*.

Modelling: As in Figure 3, the CAO pays to the care provider (“Budget”). The system in Figure 4 is *demand-driven*. The value exchanges “Budget” and “AWBZ product” are at the same value interface, which states that the care provider receives “Budget” depending on what products were delivered to the patients. This is different from Figure 3, where these two value exchanges were not connected by the same dependency path. Following the dependency path at the care provider, we have exchanges with the CVZ. The care provider delivers to the CVZ “Ability to deliver functions” and receives in return “Accreditation for AWBZ functions”. “Budget” and “Accreditation for AWBZ functions” are connected via the dependency path, which states that only having this accreditation a care provider can receive “Budget” from the CAO.

3.2 Second Cycle: Personal Budget and Social Chart

In this section, according to the e^3 -value/control framework, we start the new cycle. We take the model in Figure 4 as an input of the Step 1 of the second cycle. In the second cycle in Step 1 we model how the exceptional care system has changed due to new regulations introduced by the government. In Step 2 we demonstrate that the control mechanisms of the first cycle do not work anymore, causing new unsolved control problems. In Step 3 we offer new business model of an electronic marketplace in the exceptional care. This new business model also plays a role of IOCs.

3.2.1 Step 1: Introduction of Personal Budget

Due to the lack of facilities of the CAO-contracted care providers, and an increasing demand for exceptional care, this system became very expensive an inefficient, and queues of people waiting for an available care provider grew enormously. To solve this problem, the government created a possibility to receive AWBZ funding not in kind, as in the previous scenario, but in cash. The patient, entitled to the AWBZ funding, can get a sum of money (called Personal Budget) from the CAO and find a care provider himself. A care provider may be a family member or a private carer. As a result, for the same needs assessment with the

personal budget, a patient can find more man-hours of services from private carers than he would get via the CAO.

In Figure 5 the scenario with Personal Budget is modelled. Compared to Figure 4, one of the fundamental changes in the new health care system is that a patient gets a Personal Budget from the CAO and finds a care provider himself. A care provider does not operate via the CAO, and does not need the accreditation from the CVZ. Therefore, we distinguish two types of care providers: (regular) care providers and alternative care providers.

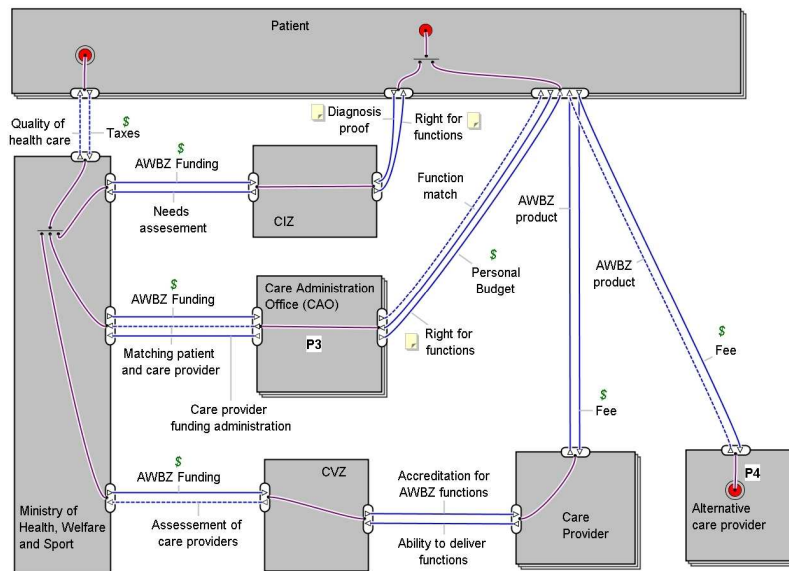


Figure 5. Control problems with the Personal Budget system

3.2.2 Step 2: Problems Caused by the Introduction of Personal Budget

We found two control problems in the scenario in Figure 5.

Control problem 3: Patients have insufficient information about alternative care providers

Description: The first problem is that the patients and their family members are not well-informed about available alternative care providers. As it became clear from the interviews with experts, due to this knowledge asymmetry, the patients tend to select well-known service providers, offered by the CAO, rather than alternative providers. This may result in low usage of alternative providers'

services, and in an insufficient development of the alternative care providers market.

Modelling: In Figure 5 this problem is expressed by making the value exchange “Product match” between the CAO and the patients a sub-ideal value exchange. This results in the sub-ideal exchange “Matching patient and care provider” between the CAO and the ministry. The CAO is assigned a penalty P3.

We should mention that this problem is not a typical control problem caused by fraud or an error by one of the actors. This problem belongs to a kind of management control problems, related to low organisational performance (see section 2). In our case we have low inter-organisational performance. We are able to model this performance-related problem with the e^3 -value/control methodology.

Control problem 4: Risk of low quality of alternative care providers

Description: The second problem is related to the risk of low quality of products delivered by alternative care providers. In case of traditional care providers, the quality control is performed directly by the CVZ. In case of alternative care providers, such a direct quality control is very expensive. The market of alternative care providers is expected to expand enormously in upcoming years; there will be thousands of new alternative care providers. For example, even the care of a patient provided by a relative can be considered as an alternative care provider. Hence, it will be undoable for the CVZ to perform a quality control for all these new alternative providers.

Modelling: This problem is modelled by marking the exchange of AWBZ product between the patient and the alternative care provider dashed. A penalty P4 is assigned to the alternative care provider.

3.2.3 Step 3: A Future Scenario: the Social Chart

To solve the control problems 3 and 4, in Figure 6, which depicts the future scenario, we introduced a new actor, called Social Chart. The Social Chart is an information web-site for patients and their carers. The concept of the Social Chart was proposed in the FRUX project (Droes et.al. 2005). Following our framework, we explain how the Social Chart can solve the control problems 3 and 4.

Control mechanism 3 – Social Chart provides Specific Product Advice

Description: The control problem 3 is related to the lack of information about alternative care providers. To solve this problem, the Social Chart provides a specific product advice. This specific product advice is online information about alternative care providers. The Social Chart in the FRUX project is targeted at providers for a specific group of illness, for example, providers for patients with dementia.

Modelling: In Figure 6 the Social Chart is introduced as a new actor. The Social Chart delivers to the patients a service “Alternative care provider advice”. As a result, the value exchange “Matching patient and care provider” is exchanged with the CAOs and the exchange “Matching patient and care provider” between the CAO and the ministry is not sub-ideal, as in Figure 5. The penalty P3 is still assigned to the CAO, because the CAO did not change its behaviour. The value exchange “Function match” is still sub-ideal. The other sub-ideal value exchanges were corrected due to the introduction of the new exchange “Alternative care provider advice” with the Social Chart.

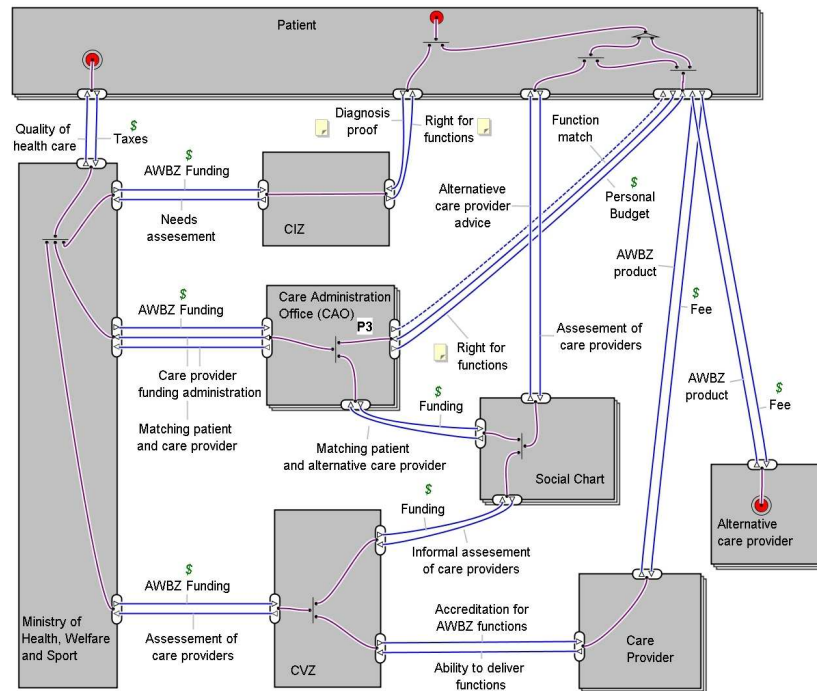


Figure 6. Role of Social Chart: control of quality and alternative care provider match

Control mechanism 4 – Social Chart provides Informal Quality Control

Description: The problem 4 is related to the absence of quality control of alternative care providers. To tackle this problem, we propose that the Social Chart provides informal quality control facilities. For example, by enabling a peer review by an online community as described in Dannecker, Lechner (2004). In this way the Social Chart web-site can provide an informal quality assessment

instrument. This can be a forum or a rating mechanism, where the users can share their experiences about different alternative care providers, comparable to the book review system in the online bookshop Amazon.com. In this manner the knowledge about the quality of products can be shared. As a result, people will prefer services that are recommended by others to have a better quality.

Modelling: The quality assessment facility is a service provided by the Social chart to the patients. In Figure 6 the Social Chart gets in return from the patients the “Assessment of care providers”. The value exchange “Informal assessment of care providers” is introduced between the Social Chart and the CVZ.

Because these problems are important for the government, we suppose that they are the potential funding source for the Social Chart. In Figure 6 we modelled the Social Chart funded by both the CVZ and CAO. Because the CVZ is responsible for monitoring the quality of care providers, they might be interested in funding the Social Chart. Another source of funding is by the CAO; in return for a better patient and provider matching. This model is only one of the many options.

4 Conclusions

One of the goals of this case study was to investigate the potential use of the *e³-value/control* methodology for the analysis of control problems in network business models and for discovering new business opportunities related to the solutions of these control problems. By applying the three-step approach we analysed in a structured way the changes in the health care system at various stages, and represented it from the value perspective. We also modelled the Social Chart. Initially, it was unclear what the commercial value of the Social Chart in the new health care system is, and why the government should pay for it. During this modelling process we explicitly modelled the value of the Social Chart for the government. Furthermore, we proposed an additional online community functionality of the Social Chart for informal quality assessment of alternative care providers, which was not considered in its initial version (Droes et.al. 2005). In particular, this informal quality assessment is expected to contribute significantly to the value of the Social Chart. As a result we also achieved the other goal of the paper and were able to analyse opportunities of the Social Chart.

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Appendix

Description of e3value concepts.

Actor. An actor is perceived by its environment as an independent economic (and often legal) entity. An actor makes a profit or increases its utility. In a sound, sustainable, business model *each* actor should be capable of making profit.

Value Object. Actors exchange value objects, which are services, products, money, or even consumer experiences. The important point here is that a value object is *of value* for one or more actors.

Value Port. An actor uses a value port to show to its environment that it wants to provide or request value objects. The concept of port enables to abstract away from the internal business processes, and to focus only on how external actors and other components of the business model can be 'plugged in'.

Value Interface. Actors have one or more value interfaces, grouping reciprocal, opposite-directed value ports. A value interface shows the value object an actor is willing to exchange, *in return for* another value object via its ports. The exchange of value objects is atomic at the level of the value interface.

Value Exchange. A value exchange is used to connect two value ports with each other. It represents one or more *potential* trades of value objects between value ports.

With the concepts introduced so far, we can explain who wants to exchange values with whom, but we cannot yet explain what happens in response to a particular end-consumer need. For this purpose we include in the value model a representation of *dependency paths* (based on [Buhr]) between value interfaces. A dependency path connects the value interfaces in an actor and represents triggering relations between these interfaces. A dependency path consists of dependency nodes and segments.

Dependency node. A dependency node is a stimulus (represented by a bullet), a value interface, an AND-fork or AND-join (short line), an OR-fork or OR-join (triangle), or an end node (bull's eye). A stimulus represents a consumer need; an end node represents final state in a model.

Dependency segment. A dependency segment connects dependency nodes and value interfaces. It is represented by a link.

Dependency path. A dependency path is a set of dependency nodes and segments that leads from a start stimulus (also called a **consumer need**) to an end stimulus. A path indicates that if values are exchanged via a value interface, then other value interfaces, connected by the path, also exchange values.