Human Centric Design in Smartcity Technologies

Implications for the Governance, Control and Performance Evaluation of Mobility Ecosystems

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ABSTRACT

Governance can be understood as the system by which actors in society are directed and controlled. Given the trinity "Institution, Market and Organization" a pressing question is: which governance structure minimizes the transaction costs in governing and controlling in the build and service design for organizations similar to a city? We investigate the notion of the governance of common goods and the problem of organizations - how or when to balance control mechanisms. As Tirole observes there is a need to explicate incentives for all stakeholders on the basis of some measure of aggregate welfare of all stakeholders. In this paper we develop a mathematical model to explicate information needs in a bilateral contract and use these insights in the case study, initialized and inspired by the procurement process of transport services at the care institution in the Netherlands in 2020 and 2021. Our results show that the information problem emerges when the object of what is exchanged between two parties is not considered as the unit of analysis. Once we understand the nature of the bilateral exchange relationship then we are able to consider the consequences of the control loss causing transaction costs due to conflicting objectives, moral hazard, adverse selection, opportunism and so on.

CCS CONCEPTS

• **Human-centered computing**;

KEYWORDS

human centricity, graphs, networks, common good, governance, control, performance evaluation

ACM Reference Format:
Rob Christiaanse. 2022. Human Centric Design in Smartcity Technologies: Implications for the Governance, Control and Performance Evaluation of Mobility Ecosystems. In *Companion Proceedings of the Web Conference 2022 (WWW '22 Companion), April 25–29, 2022, Virtual Event, Lyon, France.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3487553.3524847

1 INTRODUCTION

Before the smart city concept emerged, smart growth was in the early nineties of the last century the most used term entailing a strong government and community driven reaction to the ongoing worsening trends in traffic congestion, school overcrowding, air pollution, loss of open space accompanied by ever-growing public facility costs [27]. The key idea buttressing the smart city concept is that the concept, as a model, can serve as a mitigation strategy, from a governance point of view, to solve aforementioned urban problems to make a city a better place to live [16]. Due to advanced information and communication technologies the smart city concept has taken a data-driven direction in building critical infrastructures and service design of a city. The advanced nature of current information and communication technologies lies in the realm of artificial intelligence and robotics. Smartness in the technology context implies self configuration, self healing, self protection and self optimization. Needless to say that the level of autonomy is a profound characteristic of what we coin as a decentralized autonomous mechanism defining a smart ecosystem [22]. To be more specific in the case we infuse information into physical infrastructures to improve convenience , facilitate mobility, add efficiencies in service processes, conserve energy, improve the quality of air and water, deploy resources effectively and share data to enable collaboration between stakeholders, make better policies and improves decision making we need to think about which governance mechanism fits this new reality we coin as a socio technical system [12]. A rational actor will prefer the governance structure with the lowest transaction costs [43]. In transaction cost economics, transaction costs are defined as "The ex ante costs of searching, drafting, negotiating and safeguarding an agreement and, more especially, the ex post costs of maladaptation and adjustment that arise when contract execution is misaligned as a result of gaps, errors, omissions, and unanticipated disturbances". It needs no elaboration that the urban problems as mentioned earlier can be coined as institutional failures causing unprecedented transaction costs born by society [44].

1.1 Problem statement

Governance can be understood as the system by which actors in society are directed and controlled. A governance structure specifies the distribution of rights and responsibilities among actors as stakeholders and spells out the rules and procedures for making decisions on actors affairs [14] [39]. Institutional failures are in a larger context the problem of common pool resources (CPR) extensively studied by Ostrom [28]. To understand CPRs it is of utmost importance to distinguish between a resource system and the flow of resource units, while still recognizing the dependence of the one tot the other. One major issue Ostrom identifies in current theories is related to what is recognized as the information problem. The issue concerns the assumption that complete information is freely available and that transaction costs can therefore be ignored.

WWW '22 Companion, April 25–29, 2022, Virtual Event, Lyon, France

ACM ISBN 978-1-4503-9130-6/22/04…$15.00
https://doi.org/10.1145/3487553.3524847

Ostrom recognizes that information can be scant, potentially biased, and very expensive to obtain.

Institutional failures share the same problem extensively studied by market - and organizational failure theorists like Williamson and Ouchi for example [45, 46, 48, 49] [29–34]. The main research question is: "Given the trinity institution, market and organization: which governance structure minimizes the transaction costs in governing and controlling in the build and service design for organizations similar to a city?"

2 RESEARCH APPROACH

Following Lewis good representations of meaning are only possible when at the same time a statement is made on how the representation of the meaning is used in for example communication and inference. Structure defined as an assembly of components should always be studied in tandem with an associated process, whatever this process may be [1, 25].

This research is in the realm of Design Science Research [23] and is to be characterized as Design Theory. In this respect this research coined as design relevant explanatory/predictive theory (DREPT) augments the "How" part or question with explanatory information on "Why" one should trust the proposed design will actually work.The key point is that the explanatory information is obtained using kernel theories. Kernel theories are established theories form social sciences, economics, mathematics, computer science, logic and so on. We are interested in theory building on how to design effective and efficient governance and control systems, of which this may be interpreted as experimental scientific investigation. The ultimate unit of analysis is the individual coined as methodological individualism. It is necessary to base all accounts of interaction on individual behavior [5, 47].

2.1 Empirical grounding

This research is initialized and inspired by the procurement process of transport services at the care institution in the Netherlands in 2020 and 2021. This research has contributed to the tentative design buttressing the governance, control and performance evaluation of e-mobility services at the care institution that offers care and support to people with intellectual disabilities, as one of the desired outputs of design science research process model in [41].

3 CHARACTERIZING SMART ECOSYSTEMS

3.1 Governance for the common good

Tirole defines corporate governance as the design of institutions that induce or force senior management to internalize the welfare of stakeholders [43]. The provision of managerial incentives and the design of the control structure must account for their impact on the welfare of stakeholders (i.e. the natural stakeholders and investors) in order to, respectively induce or force internalization.

To understand why internalization of the welfare of stakeholders is important we need to elaborate upon the notion of control rights. Control rights are defined as the right for an individual or a group of individuals to affect the course of action once an organization has started. In the case the individuals or group of individuals do not internalize the welfare of other stakeholders then externalities emerge due to the lack of convergence of objectives stakeholders hold. Divergence of objectives create externalities, which we recognize as the problem of social cost [15]. Externalities are caused by conflicting control rights. The puzzle is to find the economical, social and environmental benefits of the coexistence of multiple stakeholders. Consequently we need to explicate incentives provided by rewarding management on the basis of some measure of aggregate welfare of all stakeholders. Tirole argues that the key problem we have to face is to answer the question whether such a measure of aggregate welfare is readily available [43]. He observes that there is no accounting measure of this welfare and that it is even harder to measure the organizations' contribution to welfare of it's stakeholders then to measure the organizations' profitability. We will address the issue of measurability later on in this paper. First we need to address the issue of trust.

An optimistic view is that senior management will choose what is right for society, that is that senior management will maximize the sum of the stakeholders' surpluses. In this situation the basic assumption is that these type of organizations managed by senior management optimizing stakeholders' surpluses empower employees who will derive private benefits from realizing social, economical and environmental welfare. This view is considered naive since not all individuals or group of individuals place their own welfare above the society wants. Governments like municipalities and cities may be regarded as the ultimate stakeholder society organization. Their key challenge is to balance the welfare of many interest groups as natural stakeholders and what we coin as stakeholders by design. Institutional design is a question of relative efficiency.

There is a trade off between the situation where shared control is effective and situations where objectives are strongly diverted. In the latter case we expect that undivided control is warranted. But undivided control comes with a cost of biased decision making. It is in these circumstances that it is of utmost importance to use the contractual apparatus in order to reduce the externalities imposed by the controlling stakeholder by extending the contractual apparatus with legal and regulatory stipulations to protect the welfare of the non controlling stakeholders. This view is consistent with the findings of Greenwald and Stiglitz [18]. Markets are not contrainted Pareto efficient. They observe that "there is not a complete set of markets; information is imperfect; the commodities sold in any market are not homogeneous in all relevant aspects;it is costly to ascertain differences among the items; individuals or firms do not get paid on a piece rate basis; and there is an element of implicit or explicit insurance in almost all contractual arrangements. Consequently it is possible that Pareto improvements are feasible and can be affected through government policies by identifying the presence of inefficiencies i.e. externalities enabling to point out the appropriate direction of policy intervention and observable measures of their successful application". In the section modeling bilateral contracts we will explore this issue in detail.

3.2 The problem of organizations - how or when to balance control mechanisms?

"The problem of organization is the problem of obtaining cooperation among a collection of individuals or units who share only

partially congruent objectives. When a team of individuals collectively produces a single output, there develops the problem of how to distribute the rewards emanating from that output in such a manner that each team member is **equitably** rewarded. If equitable rewards are not forthcoming, members will, in future cooperative ventures, adjust their efforts in such a manner that all will be somewhat worse off" [30]

Now it is clear that Ouchi treats the apparent coordination and control as a measurement problem. In table 1 the conditions whether to measure behavior and or outputs are depicted. "Evidence suggests that output control occurs in response to a manager's need to provide legitimate evidence of performance, while behavior control is exerted when means-end relationships are known and thus appropriate instruction is possible" [34].

Next Ouchi investigated whether organizational structure is related to organizational control. His findings were that the structure of an organization is not isomorphic with its control system. Two major observations have to be stressed. Large organization with many hierarchies and many divisions tend to develop more complete i.e. detailed measures of output to minimize control loss within the delegation process. It needs no elaboration that the availability of these measures is a necessary condition for the application of control based on outputs. However, output measures never completely capture all of the performance goals sought by an organization. In this circumstance Ouchi observers that the presence of a training staff inhibits control loss by providing a common language and a common scale through which subjective evaluations can be made commensurable [32] [33].

"There are two underlying issues which are of central importance in determining which form of control will be more efficient. First is the question of the clarity with which performance can be assessed. Second is the degree of goal incongruence. These two dimensions are intimately related in determining the forms of control that will emerge, but each of these dimensions is shaped by an independent set of forces. The intimate relationship between the two dimensions is evidenced in the observation that high levels of goal incongruity can be tolerated only as long as performance can be evaluated with precision. Conversely, high ambiguity concerning performance can be tolerated only if goal incongruity is trivial. In everyday language, people must either be able to trust each other or to closely monitor each other if they are to engage in cooperative enterprises"[30].

3.3 Underlying logic Markets, Bureaucracies and (economic) clans

Ouchi argues that "markets, bureaucracies, and clans are three distinct mechanisms which may be present in differing degrees, in any real organization. The key question in his seminal paper "Markets, bureaucracies and clans" is to specify the conditions under which the requirements of each form are most efficiently satisfied [31]. Ouchi states that this can be done by approaching this question most effectively by examining the markets and hierarchies approach provided by Williamson [46], which builds upon earlier statements of the problem by Coase [9] and others (for a more detailed description of the functioning of each mechanism, see Ouchi [30]. First we discuss the general conditions under which form of mechanism will mediate transactions between individuals most **efficiently**. These general conditions are coined as the Organizational Failures Framework as depicted in table 2.

The normative requirements refer to the basic social agreements that all members of the transactional network must share if the network is to function efficiently, without undue costs of performance auditing or monitoring. The informational prerequisites of each form of control are prices, rules, and traditions. Prices are a highly sophisticated form of information for decision making. However, correct prices are difficult to arrive at, particularly when technological interdependence, novelty, or other forms of ambiguity obscure the boundary between tasks or individuals; therefore bureaucracies and or economical clans may be considered just because their negative side-effects (i.e control loss) may cause lower transaction costs then using formal output related (financial) controls.

4 COALITION OF BILATERAL CONTRACTS

4.1 The nature of the firm

In contemporary business environments, information and communication technology enables enterprises to implement and exploit business models based on collaboration between partners in a network. For example, in logistics, large amounts of data are being shared along the supply chain, including operational, logistic, financial and strategic planning data. Information and communication technology allows the transmission and processing of large amounts of data, necessary for synchronous decision making [38]. Agents like sellers and buyers participating in a network depend on each other; they will have to trust one another not taking advantage of each other. In particular, network participants must rely on the data being shared.

The price mechanism ensures that a market price of a good and or service accurately summarizes the vast array of information held by market participants [6]. It needs no elaboration that the information aggregation characteristic of the pricing system buttresses many theories about the communicative function of prices and the decisions participants in the marketplace make to exploit business opportunities in the creation of value. Management of enterprises decide upon a business model that depicts the transaction content, structure, and the governance designed so as to create value through the exploitation of business opportunities [2]. The transaction content refer to goods, services or the information exchanged, where the transaction structure defines the way parties i.e. agents participate in the exchange and how they are (inter)linked. Transaction governance refers to the legal form of organization, and to the incentives for the participants in transactions [10].

4.2 Modeling bilateral contracts

Contract theory in general is the study of the theory of incentives, the theory of information and the study of economic institutions [8]. Fundamentally the simple activity of exchange of goods and of services is the basis first step in any production or allocation of resources. In this respect it is the notion of value what is of interest for our purpose designing systems, particularly smart city systems. As we have seen prices in economic theory reflect the value of an exchange in the marketplace such as buying and selling transactions. In early social theory the exchange mechanism

Table 1: Measurement

Ability to measure outputs	Knowledge of the transformation process	
	Perfect	Imperfect
High	Behavior or Output measurement	Output measurement
Low	Behavior measurement	Ritual and Ceremoney Clan control

Table 2: Organizational faillures framework

Mode of control	Norm	Information
Market	Reciprocity	Prices
Bureaucracy	Reciprocity	Rules
	Legitimate authority	
Clan	Reciprocity	Traditions
	Legitimate authority	
	Common values and beliefs	

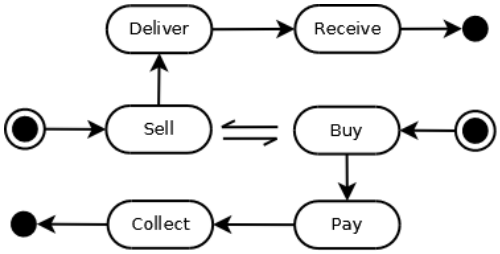


Figure 1: Value Cycle Exchange

is also used in analyzing social and anthropological mechanisms. Simmel uses the economic concept of value and argues that we should make a distinction in the exchange of value and the value exchange [40]. His first observation was that economic value is not just value in general but a definite sum of value, resulting from the commensuration of two intensities of demand to be exact the exchange of sacrifice and gain. An exchange is not a by-product of the mutual valuation of objects but its source [4]. For our purposes it suffices to look at value as defined in sociology, economics and anthropology[17]. Sociological concept of value is merely a conception of what is a good, proper, or desirable way to behave. In economic sense value refers to the degree to which objects are desired i.e. wants as measured how much others are willing "give up" to "get" these objects. Linguistically value might be defined as a meaningful difference. Hence they are all refractions of the same thing. Indeed they have some things in common and they might even share some properties which is of great theoretical and practical interest regarding the measurement problem as identified for example by Tirole and Ouchi.

4.3 Value exchange model - canonical description

Exchanges are by definition reciprocal in nature and come in a large variety of what we coin as means like signed contracts, shaking hands et cetera. For example signing a contract by both parties is performative in nature; by the act of signing, we communicate that the exchange is done. Hence a signed contract affords exchanging. An affordance establishes the relationship between an object or an environment and an organism here a (human) agent through a stimulus to perform an action. In our example the stimulus is the signed contract and the detectable change in the external environment. We assume that the agent is sensitive and therefore able to respond to external (or internal) stimuli [10].

Bilateral contracts are commonly used in business transactions. For example a sale of goods is a type of bilateral contract. The seller promises to deliver the goods or services where the buyer promises to pay for the goods by providing the seller with the indebted amount of anything parties have agreed upon. Graphically we can depict the canonical description of a value exchange cycle as in figure 1. First we have to make some remarks.

Notation 1 (Bilateral contract - Market view). *We will use the left en right harpoons exclusive for a bilateral contract among two agents* $:= S \rightleftharpoons B$. *Furthermore actions are denoted as round-edged rectangles. Action nodes are connected via arrows which specify the control flow. Together with the initial and the final node depicted as a solid circle and a solid circle surrounded with a hollow circle we have a correct descriptive model of the value exchange cycle.*

Note that money is exchanged for goods and or services. The exchange will actually occur in practice when parties agree about the contract i.e. the transaction governance, the transaction structure and the transaction contents, by the act of signing denoted by the initial node depicted as a solid circle. The contents reflect the objects of exchange. In our case good and or services. Now is is possible to extend the bilateral contract as market view as depicted in figure 2 from an organizational point of view. The final result is depicted in figure 2. This concludes our informal description of bilateral contracts used in value exchange situations.

Remark 2 (Bilateral contract - Organizational view). *Mark that the value exchange model described the sell side of agent A and the buy side of agent B. Now it is easy to see that agent A as an organization must also have a buy side otherwise he would not be able to deliver the ordered goods or services. The same type of reasoning does apply to buyer B who must also have a sell side otherwise or enough budget to consume the goods or services. By simply doubling the model of the value exchange cycle (i.e. the bilateral contract - Marker view)*

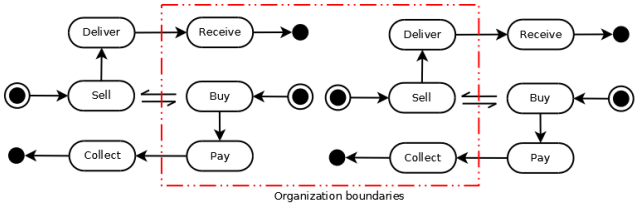


Figure 2: Value Exchange Cycle Double

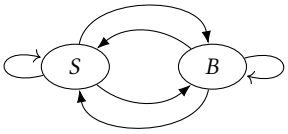
we get the precise description of the value cycle of an organization which organizational boundaries are denoted as the dashed line in red.

4.4 Value exchange model - canonical model

It is quite straightforward to translate the give and get relationship depicted in figure 1 in a mathematical graph. More specifically a give and get relationship is a directed graph. A graph is defined as follows [19].

Definition 3 (Graph). *A graph G = (V,E) is a mathematical structure consisting of two finite sets V and E. The elements of V are vertices (or nodes), and the elements of E are the edges. Each edge has a set of one or two vertices associated to it, which are called the endpoints. A formal specification of a general digraph D=(V,E, endpts, head, tail) is obtained from the formal specification of the underlying graph by adding the functions head: $E_G \longrightarrow V_G$ and tail: $E_G \longrightarrow V_G$, which designate the head vertex and the tail vertex of each arc.*

Translating the value cycle exchange market view of the bilateral contract into a directed graph gives us the following result.



As we have seen money is exchanged for goods and or services from the buyers' perspective. Goods and or services are exchanged for money from the sellers' point of view. We say that the proportion goods and or services to money equals the proportion of money to the goods and or services. So we get the following equality:

$$\frac{Goods}{Money} = \frac{Money}{Goods} \tag{1}$$

Let χ denote the goods and μ denote the money, so we get:

$$\frac{\chi}{\mu} = \frac{\mu}{\chi} \tag{2}$$

As we see the nodes S and B are in fact rationals and are defined as follows [42]:

Definition 4 (Rational number). *A rational number is an expression of the form a//b, where a and b are integers and b = non-zero; a/0 is not considered to be a rational number. Two rationals are considered to be equal, a//b=c//d, if and only if ad=bc.*

Given the definition of a rational remark that money, goods and services are not equal objects, but that the exchange relationship itself is equal. We observe that

$$S = \frac{\chi}{\mu} \Rightarrow \frac{\chi}{\mu} \cdot \frac{\mu^2}{\chi^2} \Rightarrow \frac{\mu}{\chi} = B \tag{3}$$

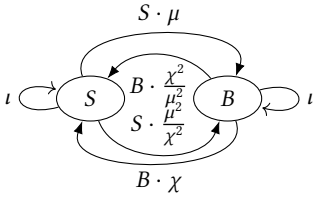
And

$$B = \frac{\mu}{\chi} \Rightarrow \frac{\mu}{\chi} \cdot \frac{\chi^2}{\mu^2} \Rightarrow \frac{\chi}{\mu} = S \tag{4}$$

It follows that S and B are equal.

$$B \cdot S = \frac{\mu^2}{\chi^2} \cdot \frac{\chi^2}{\mu^2} \tag{5}$$

More formally the bilateral exchange relationship preserves the identity of the objects denoted as rationals. Consequently S delivers χ and B pays the money μ. ι denoted as a loop in the graph serves as an explicit precondition.



Up till now our notions of goods, services and money are in fact dimensionless. That is to say we know that, after the act of signing by the parties involved in the exchange relationship, that a certain quantity of goods or services is exchanged for a certain quantity of money. Needless to say that a certain amount of money is expressed in some agreed upon currency like US $ or Euro € for example. Parties will also have agreed upon the unit of measurement of the goods or services the seller will deliver and get paid for, respectively the buyer will get received and is obliged to pay for the received goods or services from the seller. We will use the following notation.

Notation 5 (Units: measures and measurement). *The quantity of the object O is measured in some standard unit expressed as a number and a reference denoted as superscript st and superscript m, the dimension quality denoted as (q) of object, the dimension absolute frequency as a number of objects. Standard units expressed as a number and a reference $Q_O^{st}Q_O^m$ can be denoted as $U_{(}O_q)^S$ for the sell side and $U_{(}O_q)^B$ for the buy side, where U denotes the standard unit expressed as a number and a reference. The quantity of the object O is measured in some standard unit U and the measurement is expressed as a product Q · U, the dimension quality denoted as q of object, the dimension absolute frequency as a number of objects.*

We denoted χ for the goods and services and μ for money. For the sell side we get:

$$Seller\chi := \quad Q^S_{\chi_q} \cdot U^S_{\chi_q} \cdot U^S_{\chi} \tag{6}$$

$$Seller\mu := \quad Q^S_{\mu_q} \cdot U^S_{\mu_q} \cdot U^S_{\mu} \tag{7}$$

For the buy side we get:

$$Buyer\chi := \quad Q^B_{\chi_q} \cdot U^B_{\chi_q} \cdot U^B_{\chi} \tag{8}$$

$$Seller\mu := \quad Q^B_{\mu_q} \cdot U^B_{\mu_q} \cdot U^B_{\mu} \tag{9}$$

Remark that money is considered as an abstract object alike goods and services. We will explore this characteristic later in this paper. The next step is to translate the value cycle exchange market view of the bilateral contract into a directed graph representing the bilateral contract organizational view. But first we have to extend our definition for rational numbers for sum, product and negation:

Definition 6 (Rational number - sum, product and negation). *If a//b and c//d are rational numbers, we define:*

$$[sum](a//b) + (c//d) := (ad + bc)//(bd) \tag{10}$$

$$[Product](a//b) \cdot (c//d) := (ac)//(bd) \tag{11}$$

$$[Negation] - (a//b) := (-a)//b \tag{12}$$

$$[Subtraction](a//b) - (c//d) := (ad - bc)//(bd) \tag{13}$$

$$[Quotient]x/y := x \cdot y^{-1} \tag{14}$$

Next we need to consider that the basic properties of order on the rationals. We propose [42]

Proposition 7 (Basic properties of order on the rationals). *Let x, y and z be rationals, then the following properties hold:*

Laws 8. *Order trichotomy. Exactly one of the three statements x = y, x < y or x > y is true*

Laws 9. *Order is anti-symmetric. One has x < y if and only if y > x*

Laws 10. *Order is transitive. If x < y and y < z, then x < z*

Laws 11. *Addition preserves order. If x < y, then x + z < y + z*

Laws 12. *Positive multiplication preserves order. If x < y and z is positive, then xz < yz*

As we have seen the bilateral exchange relationship is in itself equal.

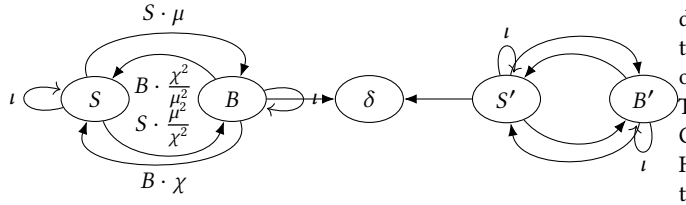
Remark 13 (Equality). *This follows from equation (3) and (4).*

Via law (8) order trichotomy we know that is must be the case that exactly one of the three statements x=y, x<y or x>y is true.In the case S=B then it must be the case that x equals y. In the case S ≠ B then it must be the case that x<y or x>y. We introduce the notion of distance.

Definition 14 (Distance δ). *Let x and y be rational numbers. The quantity |x - y| is called the distance between x and y denoted as d(x,y), thus d(x,y) :=|x-y|*

It follows that d(x,y) = 0 if and only if x=y and d(x,y) ≠ 0 if and only if x ≠ y.

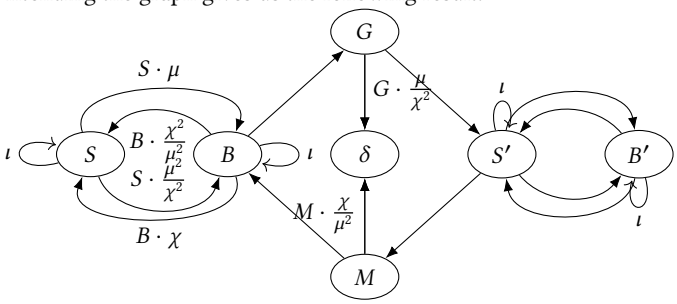
Translation of the value cycle exchange market view of the bilateral contract into a directed graph representing the bilateral contract organizational view we get the following result.



Subtraction of rationals is defined in equation 13. When we apply subtraction of x and y then we get:

$$\frac{\mu}{\chi} - \frac{\chi}{\mu} = \frac{ad - bc}{bd} = \delta \tag{15}$$

Extending the graph gives us the following result.



When we interpret the graph than it is easy to see that δ is only meaningful if and only if the units op measurement are identical. The following axioms must hold

$$Equality\ of\ units\ of\ measurement\ \chi \qquad U^S_{\chi_q} \cdot U^S_{\chi} = U^B_{\chi_q} \cdot U^B_{\chi} \tag{16}$$

$$Equality\ of\ units\ of\ measurement\ \mu \qquad U^S_{\mu_q} \cdot U^S_{\mu} = U^B_{\mu_q} \cdot U^B_{\mu} \tag{17}$$

In the case B and S' are the same agents as S and B' then δ = 0. In the case they are not the same agents then δ can have three values of which exactly one of the three statements x=y, x<y or x>y is true. It follows that:

$$Equality \qquad B + \delta = S' \tag{18}$$

$$Equality \qquad S' - \delta = B \tag{19}$$

5 GOVERNANCE, CONTROL AND PERFORMANCE EVALUATION OF SMART ECOSYSTEMS

5.1 The nature of governance and control problems

In contracting situations a principal delegates for example a task to an agent who has different objectives, then delegating this task becomes problematic when the information about the agent is imperfect. Hereafter we will explicitly make a distinction between human agents and agents which are computer systems. Following [24] "If the human agent has a different objective function but no private information, the principal could propose a contract that perfectly controls the agent and induces the latter's actions to be what he would like to do himself in a world without delegation". As a result incentive problems disappear. Alas conflicting objectives and decentralized information are two basic ingredients of information theory. We will argue that even though objectives do not conflict or information is centralized that incentive problems still can occur. Think of fraud, criminal organizations, bribery, market misconduct, CEO compensation, slavery, environmental pollution and so on. Here we enter the realm of norms and normative behavior. Three types of problems might occur in the case the human agent with

private knowledge. First we have moral hazard or hidden action issues. Secondly we have adverse selection of hidden knowledge and thirdly the case of non verifiability. Non verifiability relates to the issue of sharing ex-post the same information but that no third party or no court of law can observe this information [10].

As we stated in the introduction a smart city concept, as a model, can serve as a mitigation strategy to ensure that objectives are aligned from a governance and control point of view. A mitigation strategy entails that governments like cities, organizations and people can take measures to prevent institutional -, organizational and market failures. From a governance perspective there are several strategies to deal with governance and control risks: (1) elimination, no longer perform the risky activities, for example by refocusing the strategy or alter policies (2) centralization, restrict decision rights to senior management or governmental decision making units (3) risk-sharing, sharing risks with other stakeholders, for instance by taking out an insurance or by pooling resources together (4) automation, reducing the opportunities for violations by automating service processes, and (5) the choice for behavioral controls, reducing the risks by taking either preventative control measures, which will make the risk impossible or unlikely, or by taking detective and corrective measures, which will make the impact of the risk less severe [13].

5.2 The governance of common pool resources

We know that the lack of convergence of objectives stakeholders have externalities emerge impacting common resource pools. Externalities are caused by conflicting control rights. So in the case we are able to align the objectives stakeholders hold it is expected that externalities become internalized preserving the welfare of stakeholders. Consequently stakeholders must act as stewards safeguarding the common pool resources. As Tirole observes there is a need to explicate incentives for all stakeholders on the basis of some measure of aggregate welfare of all stakeholders. In this paper we will not elaborate on the special class of mechanisms called incentive-compatible, direct or encoded, revelation mechanisms [20, 21, 26].

Goal congruence is largely influenced by decision rights and how they are allocated among stakeholders. So we need to elicit how the decision allocation procedure is determined i.e. designed. In the situation of smart city services we have to address seven (7) questions [10]:

- What is the believe of the stakeholders with reference to the common pool resource?
- Are the values expressing common pool resources from services subsumed in other values?
- Are there several distinct values expressing the common pool resource?
- What are the value bearers of common pool resources in the service network?
- How are the decision rights dispersed in the service network, who is responsible and accountable?
- What rules, standards, regulations, rewards and punishment are established preserving (moral) values in the service network
- If applicable is there a representation expressing the (moral) value in information and communication processes?

The first four (4) bullets address the object of what is of value. In this paper we assume that stakeholders agree upon the value of a common pool resource, like clean air for example. Interpreting these arguments we can take a substantive view of value like a monist hedonist theory, or monist desire theory or a pluralistic substantive theory [36]. Once we can observe what stakeholders have decided then we are in the circumstance to interpret which view stakeholders have to what is valuable. This information is revealed by the bilateral contracts stakeholders actually agree upon in exchange relationships as elaborated upon in section 4 in this paper. Remark that this is why information is decentralized [21]. The second bullet is very interesting. The question is whether values expressing common pool resources are subsumed in other values. Here we have the problem of externalities in services for example. No doubt that clean air is a common pool resource. Car sharing services like MAAS [11] use resources like gasoline in fulfilling transport services by bringing customers from A to B. Customers pay a fare for this service in some currency. By ordering a transport, a customer buys CO2 which gas impacts the environment i.e. polluting the clean air. Indeed clean air is subsumed in the payment for taxi services. By answering the first three questions the fourth question is crucial. Simply put extending our previous example, CO2 has negative value impacting a positive value clean air. Clean air refers to the common believe of the stakeholders. The value bearer is the equality CO2 = 0. Notice there is a clear link between what agents (i.e. inhabitants, customers and so on) pay for and the common pool resource usage (see section 4.4 of this paper). The last three bullets address the design of the trinity institution, market and organization. The design enables, i.e provides in a mechanism enabling, directing (governance), controlling (structure) and evaluating services (content).

6 CASE STUDY

The care institution specializes in care and support for people with intellectual disabilities in combination with behavioral problems or, for example, autism. The organization has several locations, 24 in total, in the vicinity of Purmerend - North Holland and surroundings. The care institution provides a large variety of services like medical research and treatment, observation and crisis relief, (temporary) care for clients, education and housing, and daytime activities, work and leisure, Many clients of the care institution are not able to travel by themselves. The care institution has set itself the goal of providing transport to and from day treatments and day care for the clients indicated by it. The care institution wishes to achieve its goal by having a structured and efficient transport system organized by a professional passenger carrier.

The care institution started back in 2020 the purchase negotiations with a large passenger service provider in the Netherlands. Prior to the negotiations, the care institution drafted a so-called purchasing document, i.e. a request to make a quotation, which precisely formulated the requirements the performance of client transport had to meet. These requirements relate to service quality, safety regulations, performance evaluation and billing stipulations. Parties have agreed upon the requirements and signed of a bilateral

Table 3: Yearly key figures

Trips	Description	Object
€811.358,00	exclusive VAT 21 %	invoice
13.989	loaded billable hours	all vehicles
70.442	trips per year	all clients
39,2	weeks per year	travel period
1,797	trips per week	all clients
47	unique vehicles per day	all client trips
3,82	average trips per vehicle	
33.779	kmtrs travel distance vehicles	per week fast
30.645	kmtrs travel distance vehicles	per week short

multi year contract. Following the internal discussion within the "care institution" senior management wondered what the actual CO2 emissions were from the transport services contracted by the care institution for its clients. The underlying idea was how the care institution could contribute to its social goals and what measures management should take to make contracted transport services CO2 neutral by 2025.

6.1 Key figures exploitation transport contract

The care institution uses a modern healthcare information system to process personal data in a client-patient file. On a daily basis transport requests and changes are on a real-time basis exchanged between the care institution and the transport service provider. Changes come in a variety of types like changes in addresses, changes in the client profile and so on. Parties have agreed upon standard rest-API for the exchange of messages between the planning and reservation system of the healthcare provider and the carrier. All data are stored in a Microsoft SQL server database. In table 3 we have listed some key figures about the transportation services.

In the first line of table 3 we see the actual costs i.e. expenditures for the care institution on a yearly basis. The second line gives us the actual services the care institution bought from the transport provider on a yearly basis. Mark that these figures are the basic figures expressed in equation 1 summed over a period of one year. The care institution pays for every unique route per day the actual usage of the vehicle defined as the loaded billable hours (see figure 3 vehicle route example)

For every route the vehicle traces are registered in the database. In figure 4 we have listed the usage metrics measured in hours, minutes and seconds. For every vehicle route we have also the distance metrics measured in meters optimized for the shortest route and the fasted route as well as the x,y-coordinates and time stamps during the route execution. In the first column the zip-codes are listed, the second column depicts the ordered time of arrival, the third and fourth column gives the destination address, the fifth and sixth column gives the planned expected pick-up time and drop-off time and the seventh and eighth column gives the actual realized pick-up and drop-off time. This makes the vehicle and the client the unit of analysis. Mark that we can easily compute the distance traveled by the vehicle by using standard vehicle planning

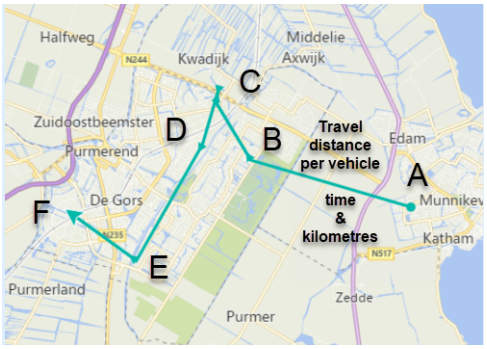


Figure 3: care institution vehicle route example

PC	Besteld	Naar	PC	PlanIn	PlanUit	Realisatie In	Realisatie uit
1132AX	9:00	ATP	1448NL	8:05	9:00	8:06:12	9:14:09
1443WH	9:00	ATP	1448NL	8:38	9:00	8:50:53	9:14:13
1447XD	9:00	ATP	1448NL	8:48	9:00	9:04:10	9:14:13
1443WH	9:00	ATP	1448NL	8:37	9:00	8:50:50	9:14:11
1444JE	9:00	ATP	1448NL	8:26	9:00	8:35:37	9:14:11
1443WH	9:00	ATP	1448NL	8:37	9:00	8:50:50	9:14:12
1446EN	9:00	ATP	1448NL	8:19	9:00	8:26:12	9:14:10
1444JD	9:00	ATP	1448NL	8:28	9:00	8:40:44	9:14:08

Figure 4: care institution vehicle trace route example

Table 4: CO2 emission procured transportation services

Trips	Unit measurement	Objects
6.760.124	Gram/CO2	all vehicles November-2021
307.278	Gram/CO2 per day	all vehicles November-2021
60.226.376	Gram/CO2 per year	all vehicles 2021

software as Google maps, open street data or Andes data solutions [3] combined with ZIP code databases [35].

6.2 Carbon footprint of transport services

As we stated earlier senior management of the care institution is interested in the carbon-footprint of the procured transport services. In the Netherlands the national rad traffic services (RDW) provides in open data about all types of transportation i.e. mobility data in the Netherlands [37]. The RDW is a tariff-financed independent administrative body that carries out tasks under the responsibility of the Ministry of Infrastructure and Water Management. The RDW provides per data set an api which enables people to retrieve the data they want. In our case we have accessed the data set which contains all type of vehicle related data such as, number plate, type of vehicle, brand, series designation, and the CO2 emission per kilometer. By combining the internal data set with the external RDW data set we have the exact carbon emissions per vehicle route.

Extending **equation8** by the unit of measurement of carbon emissions defined as gram CO2 per kilometer, we can calculate the carbon footprint of the procured transportation services quite easily by multiplying the loaded billable hour per route times the proportional relationship between the distance covered in the route and the loaded time of the vehicle. The results are listed in table 4.

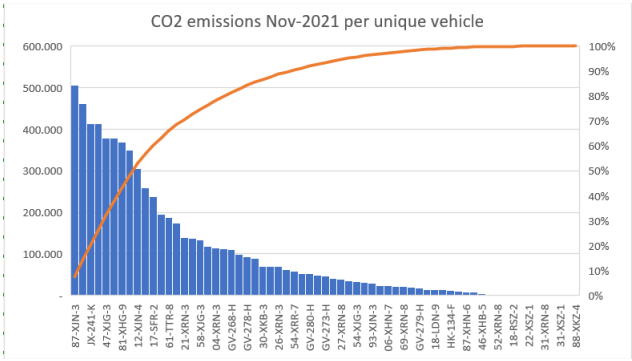


Figure 5: Vehicle emissions 2021-Nov

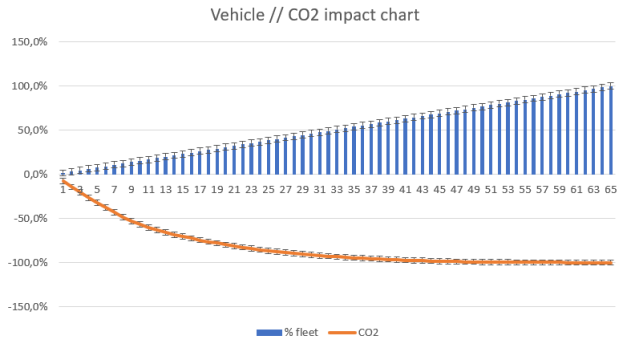


Figure 6: Vehicle CO2 impact

Now it becomes interesting which vehicle contributes in what proportion to the carbon footprint. We can use for this purpose rank order metrics. In figure 5 we have depicted a Pareto chart on the November data. The pattern we see is a familiar distribution also known as Benford's Law [7].

The key point here is that only 30 % of the vehicle fleet causes +80 % of the carbon impact op the care institution (see figure 6).

6.3 Evaluation and results case study

The key question underlying to make contracted transport services CO2 neutral in 2025, is which measures should senior management consider. On a yearly basis the contracted services for client transportation cause 60,226 ton/CO2. Considering the multiyear bilateral contract there is room to consider i.e. to come up with a plan considering the replacement investments of the vehicle fleet to electrical vehicles. We know that the average depreciation period is about 5 to 6 years. In three years time +80 % carbon emissions can be reduced by replacing 30 % of the vehicle fleet. If we look at the figures closely the first 5 replaced vehicles contribute more than 30 % of the reduction. Both parties benefit from this arrangement i.e. agreement because it is social beneficent, clean air is promoted, the agreement is economical sound and the measure is very simple to implement. Next to these measure the measured CO2 performance made lower management and staff aware that there were more possibilities. A plan was made to in-source some very expensive vehicle routes and staffed them by themselves by Prensenstichting personnel and volunteers. Three electrical buses and one normal car are bought suitable for transportation of clients. Next to the large economical benefit there was a clear motivational benefit felt by the clients and staff.

7 CONCLUSION AND FINAL REMARKS

We asked ourselves "Given the trinity institution, market and organization: which governance structure minimizes the transaction costs in governing and controlling in the build and service design for organizations similar to a city?" Four dimensions are very important to determine the form of control being the most efficient one. First clarity in which the performance can be addressed. Secondly the ability to measure the output. Thirdly the knowledge of the transformation process. The fourth dimension relates to the notion of goal in-congruence. The first two dimensions relate to what we coin as the information problem. Dimensions three and four concerns the concept of the allocation of decision rights. In this paper we analyzed that the information problem emerges when the object of what is exchanged between two parties is not considered as the unit of analysis. Once we understand the nature of the bilateral exchange relationship then we are able to consider the consequences of the control loss causing transaction costs due to conflicting objectives, moral hazard, adverse selection, opportunism and so on. In this paper we used a mathematical model to determine the minimum amount of data, as attributes in a database, to evaluate the performance. These insights minimized the governance and control risks. Simple measures were feasible for senior management to decide upon in consultation with the transport service provider. We have shown that the trinity "Institution, Market and Organization" share the same problems as illustrated by the case study at the care institution. Having a clear ambition i.e. a clear view of the actual performance and a sufficient design of the information infrastructure gives input for the control choices to govern relationships.

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