Understanding financial sustainability of ICT services for social and economic development using *e^3value*

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Keywords: ICT4D, service modelling, financial sustainability

1 Introduction

ICT4D (Information and communication technologies for social and economic development), is the endeavor to make information and communication technologies available in developing regions, where people are still 'unconnected' (e.g. [Unwin, 2009, Group, 2016, USAID, 2017, Schmida et al., 2017].

Poverty in remote rural areas of the world, such as Sub-Sahara or South East Asia, is often associated with lack of information: e.g. on markets, cus-

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tomers, agricultural inputs. Services that provide access to such information and improve the communication are supposed to contribute positively to social and economic conditions.

Since market-driven service development lags behind in low resource regions, *donor funding* is often provided to kick-start the service development process and 'connect the unconnected' through short term projects funded by public or private donors e.g. by the United Nations, USAID, the World Bank, and many other donors [Group, 2011, Schmida et al., 2017]. These service-development projects are supposed to become financially sustainable, after the end of a certain project or pilot period. In practice however, making ICT services sustainable has proven to be problematic, as mentioned in various studies (e.g.[Unwin, 2009, Marais, 2011, Kumar & Best, 2006a, Best & Kumar, 2008]). Usually, the donor decides which tools and methods are allowed to plan and monitor the progress of the project developing the service, and to evaluate its outcomes and impact. To our experience in the project execution life cycle, the design and evaluation of financial sustainability is often omitted. Only at the end of the project, the outcomes are evaluated. The focus of these evaluation studies is on *attribution* of the observed change to the *provided donor funds* [Gertler et al., 2016], and not on changes themselves. Evaluation of quantitative financial aspects (e.g can the service sustain once donor funding disappears) is seldom done. If done at all, sustainability assessments of ICT4D projects commonly consist of impact analyses, performed some time after deployment (e.g. [Kumar & Best, 2006b, Hosman & Fife, 2008]. These impact analyses [Hosman & Fife, 2008, Harris, 2001, Harris et al., 2003] look at the effects of technology use in a development context, but do not provide information about the sustainability of the service provisioning itself. In addition to taking into account financial sustainability as a project evaluation criterion by donors, we claim that financial sustainability should be a design consideration while developing new ICT4D services also.

To the best of our knowledge, no systematic and quantitative methods to systematically understand financial feasibility of ICT4D projects, either during project development or afterwards do exist. In this paper, we propose a method to include the concern of *financial* sustainability in ICT4D. Sustainability here is used in the sense of a commercially viable service, meaning not relying on government or donor funding. Therefore, the contribution of this paper is to introduce a conceptual-model based method, based on e^3*value* , to increase understanding of the financial sustainability of ICT4D services.

This paper is structured as follows. Section 2 elaborates on the requirements with respect understanding of financial sustainability of ICT4D services. Section 3 proposes a *conceptual model*-based approach for understanding financial sustainability, based on the e^3*value* methodology. To understand whether e^3*value* is of use in ICT4D projects, we employ a Technical Action Research (TAR) approach, as outlined in Section 4. TAR starts with treatment design, which we explain in Section 5. The proposed approach is then executed in two case studies as reported in section 6. Two case studies on different continents are presented and we discuss how to build and evaluated the e^3*value* models in six steps. The first case study is about the pre-analysis of community radio journalism for rural community in Mali, Africa, and considers financial sustainability assessment as part of the service design process. This is followed by a post-mortem analysis of a community e-Commerce project for the Penan community in Long Lamai, Miri, Sarawak, Malaysia. We reflect on the treatments in Section 7. Finally, the paper presents conclusions in section 8.

2 Requirements for understanding financial sustainability of ICT4D services

Over the past 10 years, we have carried out many, often technology oriented, ICT4D projects. Based on our experience, we summarize below three requirements with respect to ICT4D financial sustainability assessment.

In many projects we have worked on, there are a number of actors involved in service production, provisioning and consumption. Examples include a service to broadcast messages (such as 'I lost my cow') to an audience, local weather forecasting based on sensors in the field, and reserving a stay at a local family for a a couple of days. A message which is broadcast to announce that someone lost his cow, requires the farmer himself, a radio station to broadcast the message, people who listen to the radio, and someone who delivers the message from the farmer who lost his cow to the radio station. We argue that in order to arrive a sustainable service, it should be possible for all stakeholders participating in the service to create a net positive cash flow, or to increase their economic utility. This results in the first requirement for a method to understand financial sustainability of ICT4D services:

RQ1: All actors of the community involved in the provisioning of an ICT4D service should be financially sustainable.

In contrast to business development of ICT services in the western world, ICT4D service development projects are often funded by donor parties (UN, Worldbank, EU, national funders). These donor-funded ICT4D projects follow a different path before reaching the customer. Project goals are defined at the donor level and implemented by practitioners (Non Governmental Organizations (NGOs), private businesses and development practitioners) that have been selected according to a strict procurement procedure. In many cases, ICT4D projects start with a technical deployment plan immediately for the service, without understanding the relevant *value propositions at all.* In brief, a value proposition is an object (e.g. a service or a physical good) that is of economic value for at least one actor, for wich that actor is willing to give an economic reciprocal object (often money). Value propositions, and their corresponding payments, are needed to make a profit, and hence directly influence financial sustainability of actor. Therefore, the value propositions should be thoroughly understood, and be realistic. Therefore, the next requirement is :

RQ2: Value propositions should be realistic, and contribute to the financial sustainability of the actors.

Although we strongly argue that financial sustainability assessment, and proceeding to that, understanding of the value propositions and the reciprocal money transfers, is important to include *early* in the ICT4D service development process, it also important to analyze project results *once they are deployed*, so after the design of the service. Therefore, we formulate the fourth requirement as follows:

RQ3: The financial sustainability method should be applicable *during* service design and *afterwards*, as evaluation instrument.

The proposed method in this paper is based on the well-known e^3*value* method [Gordijn & Akkermans, 2018]. In brief, the e^3*value* method designs a network of actors, who are offering each other value propositions and reciprocal objects (e.g. payments). Additionally, the method allows for software-assisted financial sustainability assessments.

The e^3*value* method is taken as a point-of-departure for a number of reasons. First, the e^3*value* method considers the network of actors (companies, end-users, NGO's) as first class citizen. The method is flexible with respect to model boundaries. It is up to the model developer to include actors or not. However, an actor must be included if it subject to financial sustainability assessment (RQ1). Most methods in business model design (e.g. [Osterwalder et al., 2009]) take a *single enterprise* perspective: they consider only one focal actor (the one offering the service) but ignore the full business network. As many ICT4D projects are community driven, and hence have multiple focal actors by definition, this does not work. Second, in e^3*value* , value propositions in terms of *value object*s can be presented, as well as the reciprocal value objects (RQ2). Third, the e^3*value* method is useful to design the value proposition and the corresponding actor network early in the process, but also to analyze an ICT4D project afterwards (RQ3). In a sense the method is agnostic to where it is applied in the process. In this paper, we give two cases: one how we used e^3*value* to design a new ICT4D service (see Sec.6.1), and another one how we used e^3*value* to analyze an ICT4D project after its execution (see Sec.6.2).

3 Introducing the e^3*value* methodology

For our assessment of ICT services, we assume that ICT services are delivered within a *network of parties*, including suppliers, end users, and other required business actors, who exchange things (called value objects) of *economic value* with each other. We model and analyze this network in a structured way. We use the e^3*value* method, which is appropriate for this assessment.

Figure 1 introduces an educational e^3*value* model. The e^3*value* method is extensively described in literature. This paper summarizes the basics of the e^3*value* in terms of the educational model. For more information we refer to [Gordijn & Akkermans, 2018].

The key idea behind e^3*value* is the notion of a value network or value constellation [Tapscott et al., 2000] (RQ1), in which *actors* exchange (provide or require) *value objects* with each other (RQ2). These objects are of economical value for at least one of the actors in the model. In the educational example the value objects 'book' and 'money' are exchanged. More generally, one can say that a value object denotes the ownership right on some asset, or the right to experience a service.

The *actor* models a profit-and-loss responsible entity (e.g. an enterprise, here a book store or a publisher) or an end-user (here a reader of book). There can exist multiple actors of the same kind, for example multiple customers, and are called a *market segment*. These are visualized by a stack of actors (not shown in Figure 1). Market segments refer to a set of actors that assign economic value in the same way.

It is the decision of the person(s) who builds the e^3*value* model which actors are to be included. Usually, actors are included if we want to analyze their financial sustainability (the *core* actors) or if actors provide/consume value objects to/from the core actors, which we call *contextual actors*. For contextual actors, we assume that they are economically sustainable on beforehand; therefore they are not subject to financial sustainability analysis.

Actors provide or require value objects via *value ports*. The concept of 'value port' in the e^3*value* ontology is needed as an abstraction of *how* the objects are being exchanged. A value ports indicates *that* objects are provided or requested, not *how* this is done in terms of business processes.

Value ports are grouped into *value interfaces*. This interface models the notion of *economic reciprocity*: if a rational acting actor provides a value object to its environment, the same actor wants to have something in return that possesses equal or higher economic value to that actor, compared to the provided object. For example, the educational model states that money is requested in return for a book, which are both value objects.

Value transfers represent a transfer of ownership of a value object, or the right to enjoy the result of service provisioning. The e^3*value* model assumes that reciprocity exists in every value transfer, e.g. when a book is transferred, money (in casu the payment) is transferred in the opposite direction.

Central is the idea of consumer *need*. In the example, the reader has a need for reading a book. To satisfy the need, the reader must exchange value objects via its interface (money for book). To model this, the need is connected to a value interface via a *dependency path*. Also, interfaces themselves can be connected with a dependency path, for instance in case of the book store. This models that in order to sell a book, the book store must obtain a book from a publisher (and obviously pay for that).

The *boundary element* states that no further value transfers are considered. When to use a boundary element is a modelling decision. Here, the decision is

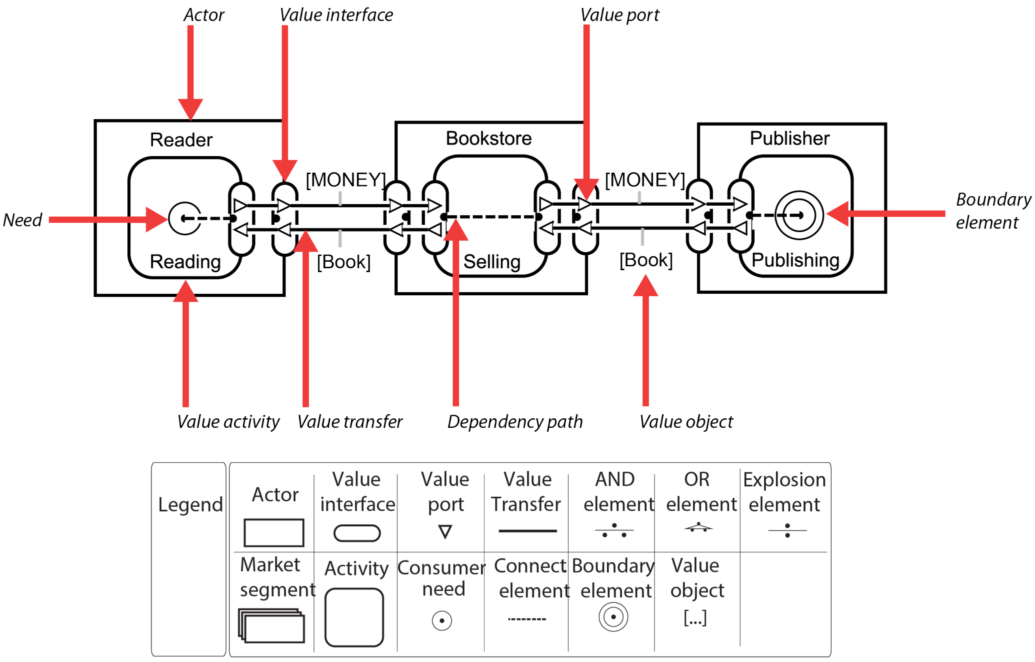

Fig. 1: An educational *e*^{3}*value* model.

taken not to further explore the transfers of the publisher anymore, hence the boundary element. Note that a dependency path does not expresses any time ordering of the value transfers. The path only states that, if a need occurs, all the transfers on the path must occur. Time ordering of the transfers is subject to a process model, e.g. in BPMN [Owen & Raj, 2003], but not important for sustainability assessment.

The *e*^{3}*value* models can be used as part of a business development process; in such a case, the value models are a design artifact describing a system *to be* developed. Alternatively, an *e*^{3}*value* model can be constructed for an already up-and-running networked value constellation, to facilitate ex-post analysis (RQ3).

For the *e*^{3}*value* technique, software tool support is available[1]. Apart from a graphical editor, the tool also provides financial assessment tools. The model constructs can be attributed with numbers. E.g., the number of customers and bookshops can be given, as well as the average price of books, the number of customer needs, etc. It is then possible to calculate the net cash flow for all the actors in the model. These cash flow sheets are a first indicator for economic sustainability of the actors and for the model as a whole.

[1] See http://research.e3value.com/

An e^3*value* sustainability analysis is typically carried out for a given time period (called the *contract period*), a month or a year, but is also possible to analyze a series of time periods (e.g. a number of years).

4 Technical Action Research: Understanding financial sustainability assessment through ICT4D field work

The method that we propose in this paper is closely related to the *design* of an ICT service, and to the evaluation of the design in terms financial sustainability evaluation of such a service, once it is a deployed. Therefore, the research we employ is closely related to Design Science [Hevner & Chatterjee, 2010]. Particularly, for this paper we use Technical Action Research (TAR) as a research methodology, because it provides a practical research methodology [Wieringa, 2014] to develop and validate a certain proposed "treatment", i.e. an artifact that aims at improving a real world problem.

The TAR method consists of four phases: (i) identifying the real world problem to be solved by a treatment (here: how to understand financial sustainability of ICT4D services), (ii) proposing a treatment (here: the approach to include economic sustainability concerns in an ICT4D service development project, or to assess sustainability afterwards (iii) applying the treatment in a real-life context (here: the treatment is applied to two different cases i.e. a community web shop in rural Sarawak, Malaysia and a voice-based radio systems in rural Mali), and (iv) reflecting on the treatment in the real-life context, with the aim of learning and improving.

5 The treatment design: Building and quantifying ICT4D services using e^3*value*

Assessment of financial sustainability of an ICT4D service using e^3*value* , consists of a number of practical steps. The steps can be executed while designing an ICT4D service, or afterwards, as an assessment instrument. The process consists of six steps and is elaborated in the following description.

Step 1: Concisely state the ICT4D idea. The idea of an ICT service or project is elaborated in this step. It is assumed that the idea is based on the needs of the community under study. Once the community needs are identified, supporting ICT services are introduced. An elaboration on how ICT services can serve the community needs is described. This is followed by an elaboration on various actors that are involved in the proposed ICT4D, the needs of the actors in relation to the proposed project and the dependency among the actors.

Step 2: Represent the ICT4D idea as an e^3value *diagram.* The concisely stated ICT4D idea and the earlier introduced e^3*value* approach (section 3) are used to construct a graphical representation of the ICT4D idea. Typically, a series of workshops with the stakeholders involved in the ICT4D idea is necessary to arrive at an *e*^{3}*value* diagram that is agreed upon by all these stakeholders, and represents the ICT4D service adequately.

Step 3: Assess economic sustainability from a qualitative point of view. From the *e*^{3}*value* model, we can assess the economic sustainability of ICT4D in a qualitative manner. Depending on the actual case, useful observations can be done without doing calculations at all. As a general rule, each actor should have more money flowing in than out on a long term. If the quantification shows no marginal profit for a particular actor, the diagram is clearly not sustainable for that actor.

Step 4: Attribute the constructs in the e^{3}value *diagram with numbers.* This step quantifies the *e*^{3}*value* model to assess economic sustainability of the ICT4D service at the hand. The quantification is done based on the following rules. If the *e*^{3}*value* methodology is used to *design* an ICT4D service, this quantification is always an estimate. If the assessment is done while the ICT4D service is already *up-and-running*, the quantification should be based on actual numbers of the case.

Before quantification starts, it is necessary to agree upon the time frame the *e*^{3}*value* diagram spans. Typically, a time frame of one year is used, however, it is equally well possible that the time frame is a month, week, or day. The *e*^{3}*value* methodology is capable of dealing with multiple sequential time frames (e.g. multiple years). In this study, we restrict ourselves to one time frame (the so-called *steady-state*), specifically one year of execution of the ICT4D service. We suppose that such a year represents the situation after initial investment (e.g. by donor funding) and therefore should be sustainable.

Quantification has three steps:

1. Quantification of the price of the service. Most services require payment in the form of a money transfer. The amount of money to be paid must be known.
2. Quantification of the number of actors. The *e*^{3}*value* notion of 'Market segment' represents a set of actors. It is for example used to model that a service has many customers (the market segment). The number of actors in a market segment (e.g. the number of customers) has to be quantified.
3. Quantification of the number of customer needs. Per contract period, say one year, a customer can have a number of needs.

Step 5: Assess economic sustainability from a quantitative point of view. In this step, the *e*^{3}*value* software is used to conduct a quantitative analysis of the *e*^{3}*value* model. If the quantification was done correctly, the *e*^{3}*value* software can generate a net value flow sheet for each actor. The net value flow sheet presents the net value flow within a particular time frame. The flow present a monetary unit for each value transaction. Clearly, if this flow is a negative value (on the long term), the ICT4D service can not be considered as sustainable.

In order for the ICT4D idea to be sustainable, *all* the actors in the diagram should have a positive net cash flow. If an actor has a positive net cash flow, this net amount of money should be used to cover all expenses not presented in the model. Alternatively, these expenses could be included in the model also. The e^3*value* methodology supports fixed-, and variable expenses, and one-time investments.

Step 6: Improve the ICT4D idea and e^3value *model.* The proposed sustainability analysis is done in an iterative manner. The iterative evaluation design is adopted when assessing sustainable on-going ICT projects in [Bon et al., 2016]. It is normal that a first version of the e^3*value* model may not produce a sustainable result. In order to improve the model, the model and the quantification of e^3*value* model need to be changed. The generated net value flow sheets indicate which actors experience problems. We can modify those values in order to produce a net positive value flow for all actors.

6 Treatments: Two ICT4D cases

To validate our method, we have carried two case studies. The first case study is about an ICT4D service development project on community radio journalism for rural communities in Mali, Africa. Here, e^3*value* was used as design tool to understand the network of actors, and to assess the the service under study for financial sustainability. The second case study is a post-mortem analysis of a community e-Commerce project for the Penan community in Long Lamai, Miri, Sarawak, Malaysia. The e^3*value* method was applied here to show why the project at hand was not financially sustainable at all.

6.1 Treatment I: Community radio journalism for rural area Mali

This case study was carried out in Mali by two of the co-authors of this paper. Here, the e^3*value* method was used as an explicit design step in a series of workshops in Africa. The case study comprises a service to broadcast messages via a radio station that come from people of various rural communities.

Step 1: Concisely state the ICT4D idea. In Mali, many community radio stations exist. Some of these community radios are state funded and connected to the national broadcasting service ORTM (Office Radio Television du Mali), and others are privately funded or completely self-supporting. Some radio stations do have computers and internet. Other radio stations have computers without internet connection and some do not have any computer facilities at all. However, such radio stations are situated within the coverage area of mobile telephony, thus allowing for internet connectivity via the mobile phone network.

The radio stations want to have a message system for citizen journalism, accessible through phone. In short, such a system should allow citizen journalists to deliver voice messages to the radio station via a voice response system. The radio station should be able to retrieve the messages and broadcast the messages. The messages are short news reports from villages.

Fig. 2: Radio station at Tominian, Mali.

The message system, nicknamed Foroba Blon (FB) [Gyan et al., 2013, Bon et al., 2012], is a platform that supports rural radio stations and provides them with a tool to easily store, manage and process incoming voice messages from their reporters. The rural radios receive voice messages for broadcasting, but these are usually written on paper. The citizen journalists bring the messages to the radio station, where they are read aloud on the radio by the journalist. The idea behing FB is to improve this process by allowing customers to phone in and send a message that they want to be broadcast on the radio. It provides the radio journalist a means to receive the voice messages asynchronously, store them as audio files, select, add meta-information, and manage them so that they can be broadcast at any given moment.

Step 2: Represent the ICT4D idea as an e^{3}value *diagram.* Figure 3 presents the *e*^{3}*value* model for the FB platform. There are six actors involved. The actors are customer, village reporter, radio station, telco, FB service provider and listener.

The customer is a person living in a remote village in Mali (e.g. Konobogou). The customer usually does not own a mobile phone. This person has a need (annotated #1) to announce a message to other people in the region. For instance, he wants to broadcast a message on the radio, because he is missing one of his cows. By reporting this lost animal on the local community radio, the message will be reached by 80.000 people, the listeners base of the radio station Sikidolo, in Konobougou. The customer pays for broadcasting the announcement on the radio.

The village reporter is a person in the village who owns a mobile phone. On behalf of the customer, he makes the phone call to do the announcement, e.g. concerning the lost cow, or allows the customer to do the announcement. For doing so, the customer pays a fee to the reporter. The AND-fork annotated #2 represents that the village reported has to transfer economic value objects with two actors, namely the radio station and the telco. For each announcement broadcast by the radio station, the village reporter pays the radio station an amount of money. Also, the village reporter should pay the telco a fee for the telephone connection. This is just the normal fee to be paid to a telecom operator for a voice call.

At a certain point in time, the radio station broadcasts the announcement to the listeners of the radio station. Explosion element annotated with #3 indicates that one received announcement by the radio station is broadcast to 80,000 listeners. A listener receives announcements. In general, announcements are considered as valuable to the listener because they reflect interesting content. In return for the received announcements, the give the radio station audience. As a radio station's primary goal is to serve an audience, this is of value to radio station. Optionally, the radio station can use the audience to attract other sources of revenue, e.g. advertisements (not shown in the model).

Finally, the radio station obtains the voice platform service (FB) from the FB service provider and pays for this service, including regular maintenance. As this is a monthly service, the radio station pays only once per month, therefore there is one need per month for the platform.

Step 3: Assess economic sustainability from a qualitative point of view. There are number of observations that can done by considering just the graphical

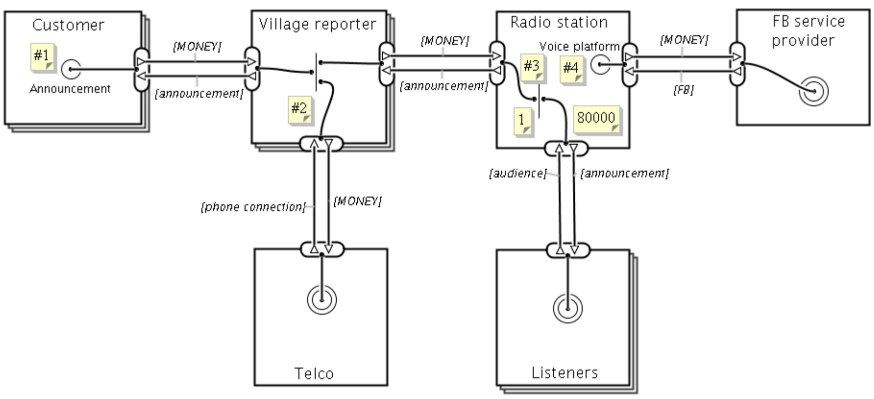

Fig. 3: An e^3value model for Foroba Blon.

Table 1: A trunk of telephone lines is not considered.

Observation 1	A trunk of telephone lines, with corresponding subscription fees are not part of the model.
Explanation	The proposed platform supposes that radio stations have their own infrastructure for handling telephone calls. The platform solves this by a GSM telephony device, which is connected to FB platform. The GSM device uses a pre-paid phone card, so there are no monthly subscription fees (only an one time investment in the pre-paid card). Therefore, monthly subscription fees are not part of model. A possible drawback is that the current platform only supports on GSM device per platform instance. This is fine for a service start up, but once the service is popular, customers may experience that the phone is occupied if they want to make an announcement. This may hinder further growth of the service.
Recommendation	There are a couple of ways dealing with a limited number of phone lines. First, the platform instances of the radio stations, each equipped with a GSM device, may use the devices of other platform instances if they are not occupied. However, this requires that radio stations exchange received messages with each other, which imposes telephone connection costs for the radio stations. Second, the platform may be hosted at a (telecom) provider, along with a trunk of land telephone lines. This however would result in expenses for hosting, as well as for telephone lines (subscription fees), and both are expensive in Mali.

model. The first observation shows that a telephone truck is missing from the model (see Table 1).

The second observation concerns the choice that the FB service is funded by only one customer (see Table 2).

Table 2: The FB service needs multiple customers.

Observation 2	One-to-one relationship between the radio station and the FB service provider.
Explanation	As can be seen from the *e*^{3}*value* diagram, the FB service provider has only one customer, namely the radio station. The pricing of the FB service provider has been chosen such that the provider at least has a positive cash flow. However, the total revenue is not sufficient for FB service provider to make a living.
Recommendation	The FB service provider needs more income. This can be achieved by attracting multiple local radio stations, operating in different geographical regions. On the short term, additional funding for the FB service provider can be arranged by donor funding. Such funding can also be used to develop and improve to FB platform. On the long term however, the FB platform should be provisioned at multiple radio stations.

Step 4: Attribute the constructs in the e^{3}value *diagram with numbers.*

1. Quantification of products and services. The customer pays for broadcasting an announcement on the radio and access to the FB platform fCFA 1,500. The alternative would be to travel to the radio station to leave the message personally. The travel to reach the radio station would cost him on average 4,000 fCFA. Consequently, we consider this not as a viable alternative and but instead as a sound motivation to use the FB service.
   The radio broadcasts the message and receives a payment for each broadcast announcement from the village reporter. The village reporter pays the radio station for each announcement fCFA 750.
   Also, the village reporter should pay the Telco for the phone call. We assume the average phone call costs fCFA 650.
   The radio station pays for the FB service be fCFA 200,000 per month.

Table 3: Prices of FB products and services

Value object	Value (fCFA)
Announcement service (customer)	fCFA 1,500 per announcement
Announcement service (reporter)	fCFA 750 per announcement
Phone call	fCFA 650 per announcement
FB service	fCFA 200,000

2. Quantification of the number of actors.
   Table 4 shows the number of customers and well as the number of village reporters. We assume 2,250 customers per all participating villages. Also, there are 85 village reporters.

Table 4: Number of actors in a market segment

Actor	Count
Customer	2,550
Village reporter	85

3. Quantification of the customer needs. There are on average two announcements per month per customer. On a daily basis, the radio station collects the submitted announcements, therefore there are on average 30 needs per month to collect such announcements. Finally, since the subscription on the FB platform is on monthly basis, there is one need per month.

Table 5: Number of customer needs

Customer need	Count /month
announcement (per customer per month)	1
FB platform	1

Step 5: Assess economic sustainability from a quantitative point of view. We use the e^3*value* tool set to generate net value flow sheets, the result is in Table 6.

Table 6: Sustainability analysis for the FB case based on the e^3*value* model.

Actor	Revenue per actor (fCFA)
Village reporter	fCFA 3,000
FB service provider	fCFA 200,000
Telco	fCFA 1,657,500
Radio station	fCFA 1,712,500
Customer	fCFA - 1,500
Listener	n.a.

Again, we summarize a few observations based on the net value flow calculations. The first observation is what we see in many other ICT4D cases also: the infrastructural service suppliers are the winners (see Table 7).

Table 7: Infrastructural service suppliers are the winners.

Observation 3	The telco and radio station are the winners
Explanation	Considering all actors in Table 8, the radio station and the telco are the parties who earn most of the money in the system. Both the radio station and telco are actors of which there is only one in the model. Naturally, these parties collect most of the money.
Recommendation	The model may benefit from competition. For the radio station, this would imply to addition of radio stations that operate in the same geographical region. This may lead to price competition between those radio stations. The same holds for the telecommunication companies; the world-wide model of mobile telephony allows competition between operators in the same geographical region.

The second observation is that the profit for the village reporter is rather low (see Table 8).

Table 8: Village reporter earns a modest amount of money

Observation 4	The village reporter earn a modest amount of money
Explanation	The village reporter only earns fCFA 3,000 per month, which is, compared to price to be paid for a single announcement by the customer, not much.
Recommendation	The revenue for the village reporter is low, but the service provided (lending the phone for a minute) is rather shallow too. Therefore, the revenue sounds not unreasonable and therefore acceptable. The low revenue is caused by the relative high number of village reporters. There is competition here, and the total amount of money related to the submission of announcements must be divided over a large number of village reporters.

Step 6: Improve the ICT4D idea and e^{3}value *diagram.* The model as proposed is useful for a field test. It has to be taken into account that FB service provider can not really make a living by having just one radio station as a customer. This can be solved with donor funding.

On the longer term, the value model should evolve:

1. More radio stations should participate. From a modelling perspective, this would imply that the radio station in the current model becomes a market segment (multiple actors) rather than one actors.
2. Radio stations that are in the same region are interesting due to competition.
3. The same hold for mobile operators; having more than one operator available would probably lower the fees. Also here, the mobile operator would from a modelling perspective change into a market segment.
4. The current technical solution, namely one mobile phone per radio station, does not really scale well, once the service gets popular. There is then an increased chance that customers will not be able to deliver their announcement. There are various ways to solve this. A first option would be to use (multiple) land lines per radio station. This requires that the radio station takes a subscription at those lines, supplied by a telecom operator. This would change the value model. A second option is that the FB platform is capable to handle phone calls other platform instances. In other words, if a customer tries to connect to particular radio station and that station is occupied, that customer is re-routed to another, not occupied radio station. Also, this option results in a change in the value model. First, radio stations many charge each other for this service, Second, radio stations need to obtain messages delivered at other radio stations using some communication mechanism for which costs are involved.

6.2 Treatment II: Community commerce for Penan community, Long Lamai, Miri, Sarawak

This case study was carried out in Sarawak, Borne, Malaysia, among others by one of the co-authors of this paper. Here, the *e^{3}value* method was used as a post-mortem analysis tool, after the project was finished. The case study is about a service sell products (e.g. craft work, home stay) of a community to the rest of the world.

Step 1: Concisely state the ICT4D idea. Long Lamai is one of the biggest and oldest settlements of the Eastern Penan in Sarawak. It is located at upper reaches of Sarawak's Baram river basin, Miri, Sarawak. Long Lamai is home to the Penan community. Shedding its traditional nomadic way of life, the Penans in Long Lamai have settled there since the 1930s under headman Belare Jabu, who was encouraged by the British colonial administration to settle along the Balong River and close to the Indonesian border. With only about six households at year 1930s, the Penan population is increased to more than 150 households nowadays. Today, the Penan live on farming, hunting and collecting of forest fruits and products. The livelihood of the Penan community is shown in figure 4.

Fig. 4: The locality and view of Long Lamai, Sarawak.

In 2006, the Long Lamai community received a tele center project. The telecenter project aimed at bridging the digital gap between the urban and Long Lamai community. Figure 5 presents the tele center, the satellite network as well as the computer facilities. The ICT equipment as well as a 4kW standalone solar PV system are hosted locally in the tele center. With the Internet facilities, the Penan community is trained to use computers and access to the Internet.

As the Penan community is good on handicraft making, crafts are sold online[2]. Also, it is possible for tourists to book a stay in the village as well as travel to the service. The eCommerce website is hosted externally, but the tele center is used by the community manage the website (e.g. offer crafts).

Step 2: Represent the ICT4D idea as an e³value *diagram.* Figure 6 presents the *e*³*value* model for the Long Lamai community. There are fourteen actors that are involved in the community. The actors are customer, traveller, web shop, craft man, home stay owner, local transporter, boat owner, national transporter, international transporter company, web hosting, inhabitant, telecenter manager, energy provider and satellite provider. The customer and traveller are the buyer of the web shop. In this model, the web shop is owned by the ISITI, Unimas. The buyer is modelled as two actors, namely customer (of crafts) and traveller (lodging).

[2] See http://www.longlamai.com/ for the eCommerce platform.

A customer buys craft(s) and pays accordingly through the web shop. This web shop is owned by the university who received funding for this particular case study. The payment includes the price of the craft, the transportation of the craft by using a boat service (Long Lamai to Long Banga) and long distance transportation (e.g. a national transporter or international transporter). A craft can be sent within Malaysia or outside Malaysia. Starting at the need (annotation #1), it can be seen that the customer exchanges money for a craft with the webshop. Following the dependency path, dependency AND element #2 shows that in order to deliver a craft to the customer, the web shop must (1) obtain the craft itself from the craft man, and (2) have transportation from Long Lamai (the community) to Long Banga (the nearest city and (3) obtain either national (in case Malaysian customers) or international transportation. The latter is shown by annotation #3: A transportation service is obtained either from a national or an international transport company. Finally, dependency element annotated #4 denotes that the boat waits until a number of crafts are ordered. Once the full capacity of the boat is utilized, the boat departs.

A traveller pays for a stay in the community, but also needs a boat to travel to the community, and local transportation (a porter) for the luggage. The need with annotation #5 represents this, and, as can be seen, in total six value transfers occur for the stay, boat, local transportation, as well as payments for these services. The dependency element marked #6, models that in order to deliver the requested services, the web shop must (1) obtain a stay from a home owner, and (2) buy a boat trip, and (3) hire a local transporter for the luggage.

The need marked #7 shows that the webs hop must obtain a website hosting service from an internet service provider. Note the dependency path

Fig. 5: Telecentre at Long Lamak.

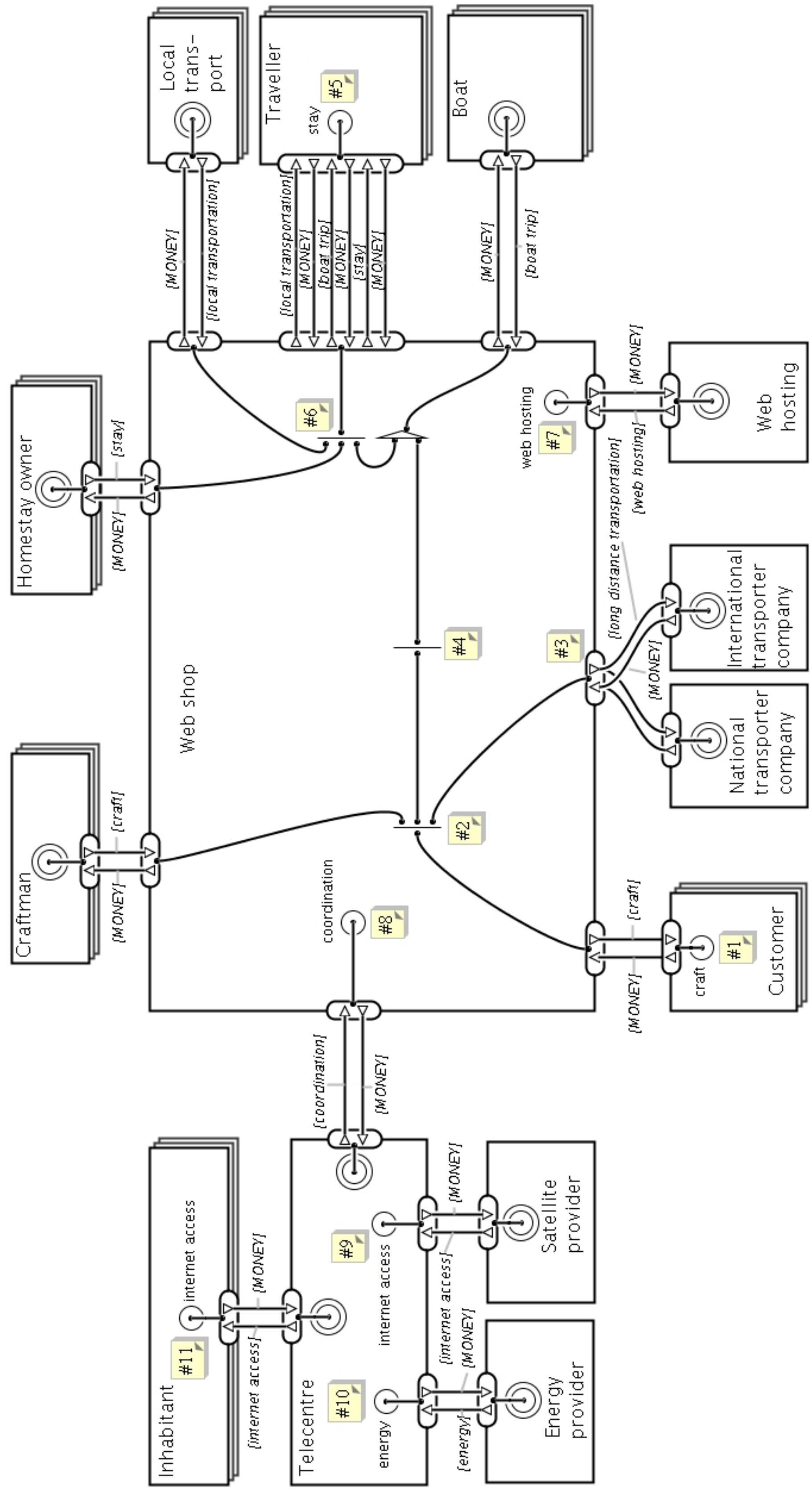

Fig. 6: The $e^3 value$ model for community commerce.

Table 9: Transportation is important.

Observation 1	Transportation is an important factor for commerce applications
Explanation	Due to geographical inaccessibility of the Long Lamai community, the delivery of the crafts utilizes a boat service (the community is only reachable by boat). Additionally, in case of international customers, there are also costs for international delivery. The same holds for the home stay service as travelers arrive by boat, and their luggage is transported by foot. Therefore, transportation costs exceed the cost of the craft and stay.
Recommendation	Transportation costs of crafts can be lowered by transporting crafts in large badges from the community to a warehouse in the city, e.g. close to the transportation company, In such a case, one-time transportation costs are divided over many craft. This requires however a warehouse facility for which has to be paid. The travel required for the home stay service is more difficult to address. One possibility is to sell the home stay service as a complete package (so including transportation) and market it well.

Table 10: Two business models.

Observation 2	Two business models in one
Explanation	Actually, the e^3*value* models consists of two sub models. One sub model considers the selling of community products and services (crafts and home stays), whereas another sub model is about the tele centre, and so about providing Internet access to the community. This leads to unclear and confusing situations, for instance that the web shop has to pay the tele centre (manager) for coordination tasks. It also means that sustainability of the web shop depends on the sustainability of the telecentre and vice versa.
Recommendation	Separate the two sub models in two e^3*value* models that each should be sustainable in their own right.

is not at all related to the previously discussed dependency paths, as the number of occurrences of the hosting need is not related to the number of needs of customers or travellers.

The need marked #8 models that the web shop needs a coordinator in the community, responsible for coordinating the craft man and home stay owners. This coordinator is the person who operates the tele center. This tele center also has two other needs (#9, #10) for internet access via the satellite, and for energy to power the tele center. Finally, the inhabitants of the community may need internet access (#11), as provided by the tele center.

Step 3: Assess economic sustainability from a qualitative point of view. There are already a number of observations that can be done based on the *structure* of the model, without even calculating the net cash flow for each actor. This shows that modelling *by itself* can already be useful for sustainability assessment, apart from the quantification. The observations are summarized in Tables 9 and 10.

Table 11: Table 1 Prices of Long Lamai products and services.

Value object	Value (Ringgit Malaysia)
Craft	RM 20 (average)
Community Internet access	RM 0
Internet satellite access	RM 1,300 per year
Energy	RM 2,000 per year
Coordination	RM 0
Homestay	RM 50 per night[3]
Local transportation service	RM 50 per day
Boat service	RM 260 (Long Bangga airport to Long Lamai) return trip[4]
Web hosting subscription	RM 269per year
National delivery service	RM 0 (the corporate social responsibility (CSR))
International delivery service	RM 300[5] per kg to European countries

Table 12: Number of actors in a market segment.

Actor	Count
Customer	200
Traveller	40
Inhabitant	100
Boat	5
Craft man	10
Home stay owner	5

Step 4: Attribute the constructs in the e^{3}value *diagram with numbers.* To be able to calculate the net cash flow for all actors in the e^3*value* diagram, the diagram must be enriched with quantitative data, which is obtained by the researchers from the ISITI, Unimas, and by web search.

1. Quantification of products and services. For products and services, customers have to pay. To calculate the expected net cash flow, the average prices of products must be know. Table 11 presents these prices in Malaysian currency. Some values listed in Table 11 are estimates by the authors, which is quite normal in business development projects.
2. Quantification of the number of actors. The e^3*value* diagram contains a number of actors of the same kind (also known in e^3*value* as market segments). Examples of such actors include the customer, the traveler, and the inhabitant. To enable cash flow calculation per actor, it necessary to estimate how many actors of a specific kind exist. We refer to this as the count of a market segment, and for the case at hand, the count for all market segments is summarized in Table 12.
3. Quantification of the customer needs. For a considered time period (here: one year), actors have a number of customer needs in e^3*value* . In this specific model, we assume that each customer need occurs precisely once in a given time period. For instance, each customer (of which there are 200) has precisely one need per year. This implies that the web shop sells 200 crafts per year.

Table 13: Number of customer needs.

Customer need	**Count / year**
craft	1
stay	1
web hosting	1
coordination	1
internet access (inhabitant)	1
energy	1
internet access (tele centre)	1

Table 14: Sustainability analysis for the community commerce case based on the e^3*value* model.

Actor	Revenue per actor (RM)
Local transportation	RM 400
Traveller	-RM 560
Boat	RM 15,600
Inhabitant	RM 0
Energy provider	RM 2,000
Satellite provider	RM 1,300
Craftman	RM 4,000
Home stay owner	RM 2,000
International transporter	RM 6,000
Customer	-RM 76
National transporter	RM 0
Tele centre	-RM 3,300
Web shop (university)	-RM 269

Step 5: Assess economic sustainability from a quantitative point of view. Based on the constructed e^3*value* model, a detailed financial sustainability assessment can be done by using the e^3*value* tool set. The tool is capable of considering a number of time periods (e.g. a number of years). The calculation in this paper is however based on the commerce activities within one year. The idea is that this year has a steady expected sales. Therefore, the quantified e^3*value* model should be sustainable for all actors involved. This means that *all* actors should be able to have a positive net cash flow. Note that the e^3*value* model does not include additional expenses, e.g. for labour. Therefore, the net cash flow generated by an actor should be sufficient for compensating all other expenses. The sustainability analysis of the actors is shown in Table 14. The calculation is based on the values from the Tables 11, 12 and 13.

Based on on the quantitative sustainability assessment, we can make a number of observations, see Tables 15 and 16.

Step 6: Improve the ICT4D idea and e^3value *diagram.* The analysis leads to a number of modifications of the e^3*value* model.

Table 15: Web shop is not sustainable.

Observation 3	Web shop is not sustainable
Explanation	The net cash flow of the web shop is -RM269. In addition to that, salary expenses have not been accounted for. Therefore, the web shop is not considered as economically sustainable. The main reason for the negative cash flow of the web shop is that there is no margin on the products and services the web shop sells. In practice, the web shop is run by using project funding, which however will end.
Recommendation	The prices to be paid by the customer and traveller should be chosen such that, on the long term, the web shop can be an independent commercial entity. This means that crafts and home stay services should be sold at a higher price than the community receives.

Table 16: Tele centre is not sustainable.

Observation 4	Tele centre is not sustainable
Explanation	The tele centre has a strong negative cash flow. This is caused by expenses for energy and internet via the satellite, whereas there is no income. For the community, internet access is free, and coordination activities for the web shop done by the tele centre are also for free
Recommendation	Charge community members for internet access. Given 100 community members, the fee to be paid for Internet access should be at least RM33 per year per community member. Additionally, coordination activities for the web shop should be decoupled from the tele centre and offered as a separate service to the web shop. The web shop should include a coordination in the prices it charges to customers.

Table 17: Local transport is not sustainable.

Observation 5	Local transportation is not sustainable
Explanation	Crafts sold by Malaysian people are delivered by a local transportation company. According to government regulation (CSR), such transportation is for free. This is fine for now, but sensitive to policy changes by the government.
Recommendation	Charge local buyers a modest fee for handling transportation. This can be used as a buffer in case transportation costs increase.

1. Two value models need to be created for (1) the craft and home stay service, and (2) Internet access for the community. Each e^3*value* model must be sustainable in its own right.
2. A warehouse of crafts should be established near to the local and international transportation service providers. On a regular basis, the community should re-stock this warehouse.
3. The web shop should have a reasonable profit margin. This results in increasing the prices charged, or lowering the expenses to craft men or home stay owners.
4. The tele centre should charge community members for Internet access.

7 Treatment Reflection: Evaluation and Improvement

7.1 Cross-case observation

The two cases share one observation that we see more often in ICT4D cases: the role of the telecommunication provider. In both cases, the telecom operator is the actor for who the business case is most beneficial. This implies also that a significant part of the donor funding is spent at telecom companies, which remains the same after the donor funding disappears. Usually, this is not inline with the goal of most donor parties, namely to (directly) help the poor.

7.2 Treatment Evaluation

We use the requirements as specified in Sec. 2 to reflect on the use of e^3*value* and the corresponding process of usage.

RQ1 **All actors of the community involved in the provisioning of an ICT4D service should be financially sustainable.**

- Selection of the actors (not) to include in an e^3*value* model is an explicit step in the methodology. The decision to include an actor or not is driven by (1) the need to assess financial sustainability for that actor (then the actor should be included plus all actors that consume or supply value objects to/from that actor), and (2) the question whether the actor is required for the other actors, but for the actor at hand financial sustainability can be safely assumed (then the actor should be included, either as consumer or supplier, but it is not necessary to include the other actors required by the actor provide the services or products). This mechanism worked well. For example in the FB case, it allowed to concentrate on certain actors for who we wanted to evaluate financial sustainability (e.g. the village reporter and the radio station), whereas for other actors (e.g. the telecommunication operator) we can safely assume financial sustainability. Nevertheless, it revealed that the telecommunication operator is the big winner in this case.
- Many ICT4D services are characterized by the notion of a 'community'. Although e^3*value* does not has the 'community' as an explicit modelling construct, we still can model the case by considering the community members as e^3*value* actors or market segments. For most cases, this is sufficient. Additionally, e^3*value* has the notion of *partnership*. With this modelling construct, it is possible to model that some actors and/or market segments *jointly* offer something of value to their environment. We have not tested this in the two cases described in this paper. However, what can not be modelled is that there are value transfers with the community *as a whole*. We have not encountered this situation in the two case studies.

RQ2 **Value propositions should be realistic, and contribute to the financial sustainability of the actors.** After analysis with the e^3*value* method, it can be claimed that an actor is financial sustainable under the conditions that

- If the analysis is ex post, the quantification should be based on the real numbers and hence correct. This happens in the Malaysian case. Here, we know the adequate numbers and hence can execute a reliable quantification. If the analysis is ex ante, such as in the Mali case, the quantification is always an estimate. Still, quantification can use reliable numbers, such as the price for a telephone call. However, e.g. the number of customer needs are to be estimated. We experienced that it is very difficult to estimate the customer base and their needs on before hand.
- All expenses and revenues can be represented in the model. It is up to the modeler to elicit all significant expenses and revenues; in other words, the method does not really provide assistance for this, apart from the enumerating the characteristics of expenses and revenues: fixed (independent from the transaction volume), one-time (for investments) and variable (directly related to the transaction volume).

RQ3 **The financial sustainability method should be applicable during service design and afterwards, as evaluation instrument.**

- If the method is applied ex ante, it is more a design method than if the method would be applied ex post. The goal of the method is then to find the actors and the value exchanges in the first place. In many cases, this is challenging task, because the value propositions (what services or products too offer) are not clear at all initially. Although not the explicit goal of this paper, the e^3*value* methodology provides guidance in this design process. This was the situation for the Mali case study.
- In case the method is applied ex post, the actors and values they exchange are already known, at least as tacit knowledge. Nevertheless, making an explicit model of the case at hand can reveal interesting details, such as in the Malaysian case that the university plays the role of the web shop, which is not desired in terms of continuity.

7.3 Treatment Improvement

Below follows a number of improvement proposals. They correspond with the issues found in the previous section.

RQ1 **All actors of the community involved in the provisioning of an ICT4D service should be financially sustainable.**

- The process used for actor inclusion in an e^3*value* model is appropriate. It keeps the model tractable and ensures that the focus is on the actors for which economic sustainability should be assessed. There is no improvement needed here.

- The e^3*value* modeling language can be extended with the notion of *community*. A way how to do in ICT4D can be found in [Sarkar & Gordijn, 2018]. The proposal is (1) to add the notion of a *group* with who others can have value transfers, and (2) to apply standard set operators between groups, market segments and actor to represent who is member of a particular market segment of or group. Note that although the market segment and group both model a set of actors, the market segment implies that in order to exchange value objects, *one* actor of the segment should be selected randomly (the assumption is that selection is based on a uniform distribution), whereas in case of a group, value exchanges are with the group *as a whole*. If it is necessary to detail the group into more detail (e.g. describing the relations between the actors in the group) is a topic for further research.

RQ2 **Value propositions should be realistic, and contribute to the financial sustainability of the actors.**
- With respect to quantification based on estimates, it is useful to extend the methodology with what-if scenarios. Such scenarios vary the estimates within a reasonable range to find out the situation when an actor is not profitable anymore. With other case studies, it is our experience that these what-if scenarios provide valuable insights regarding financial sustainability of the case at hand.
- Concerning expenses and revenues, support could be added, e.g. in the form of a taxonomy of this. For an entirely different domain, renewable energy [Gordijn & Akkermans, 2007], we have done so. The same could be done for the ICT4D service domain.

RQ3 **The financial sustainability method should be applicable during service design and afterwards, as evaluation instrument.**
- Ex ante, quantification is always based on estimates. In the current software tool, there is not really support for varying estimates in a systematic way. In a new e^3*value* tool, developed by the UT Twente [6]) there is support for varying estimates in a more systematic way.
- Ex ante and ex post, there is a need to financially assess a broad range of e^3*value* models for sustainability. In the current tool set, there is not automated supported tool set to do this efficiently. Each variation is considered as a *new* model and not as a *change* to an already existing model. There is also no support yet to compare the models in a systematic way.

8 Conclusions

This paper has presented a conceptual model-based method, to improve understandinging of financial sustainability of ICT services in low resource environments. This method, based on the e^3*value* methodology, improves un-

[6] See http://research.e3value.com/

derstanding of the underlying business model and can be used to evaluate an existing ICT-service or improve design and development of ICT-services in poor low resource environments. Two cases studies from ICT-services have shown that the model can be used in a real world setting, and that it improves understanding of the mechanisms that govern sustainability.

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