Modeling and prediction of monetary and non-monetary business values

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Abstract— **In existing business model frameworks little attention is paid to a thorough understanding of the perceived customer value of a business' offering as compared to competing offers. In this paper, we propose to use utility theory in combination with e³value models to address this issue. An actor's joint utility function specifies how much value the actor attaches to a given product or service's different qualities. Competing value offerings map to different points on the customer utility function, since they provide certain quantities of each quality. Since the customer can be expected to exhibit a utility maximizing behavior, his/her choices between offerings can be predicted. Thus, given the proposed utility extension, it becomes possible to quantitatively reason about the relative customer value of an offering compared to those of the competition. This, in turn, allows the optimization of price, the key ingredient in any business model.**

Keywords: e³value; busines models; business value, utility, profitability analysis.

I. INTRODUCTION

A business model is critical for any business venture, and especially for those that involve complex inter-organizational relationships. Several authors have proposed frameworks aimed at identifying the main ingredients of a business model (e.g., [7], [19], for an overview see [1], [32]). An important motivation behind business modeling comes from the need to assess the inter-organizational relationships in a business collaboration and to ensure that all business actors benefit from the collaboration, financially or otherwise.

During design, it is desirable to be able to predict the benefits associated with the "collaboration-to-be". Therefore some of the existing business modeling approaches not only model the business, but also propose some techniques to assess qualities such as costs and revenues [19], and profitability [7]. These approaches generally assume that realistic quantitative input data (such as cost of resources, distribution of service requests, revenues generated by delivered services, etc.) is available. However, in real life situations this type of input may be challenging to obtain. In addition, when predicting future benefits, the above-mentioned approaches do not take into account the fact that actors may not only be motivated by profit. Examples of other (hard to quantify) types of value that may drive actors to participate in collaborations are strategic partnerships, branding, trust, loyalty, etc. In this paper we propose an e³value model-based approach which uses utility theory [4], [12], [13], to quantify and analyze the business value that an actor may obtain from a collaboration. Central to the proposed approach is the calculation of a utility function for each actor. The actor's utility function can be further used as a basis for decision making under the assumption that actors exhibit a utility maximizing behavior. Thus, our approach relates business value to a utility function, which allows us not only to quantify hard-to-quantify business value types, but also provides a mathematical apparatus to deal with value maximization and decision making.

This paper adopts design science [11], [20] as research methodology. Design science is about solving problems by introducing artifacts in a context. In this study the problem is 'the difficulty of being able to predict the benefits (utility) for an actor in a "collaboration-to-be"'. The artifact that we propose is 'a utility assessment method that can be used in combination with e³value models'. Typical design science research phases are: (1) problem investigation, (2) artifact design, (3) artifact validation, (4) artifact implementation in practice. This paper is mainly about the first 3 phases.

The remainder of this paper is structured as follows. Section II introduces case examples in the scope of the Stockholm Royal Seaport Smart City project [3], which have been studied in order to gain insights in the proposed combination of e³value and utility theory. Section III provides a short description of related theory and work. The proposed approach for utility-based analysis with e³value models is explained in Section IV. This section also includes results from the case examples that have been studied. The paper ends with a conclusion.

II. CASE DESCRIPTION

The two example case studies we consider in this paper concern electric heating of 10 000 apartments during 1 year. The apartments are located in Stockholm, Sweden. The electricity consumption for heating is taken from [29], which states the ambition to spend no more than 55 kWh per square meter of an apartment per year.

The first example explores different options for electricity production and how these options fulfill the objectives of the participants. Here the apartments, called from now on households, get electricity from an electricity retailer that offers two choices. The first choice is a mix of electricity from different sources. The second choice is electricity mainly produced from wind energy. While the electricity price for the first choice is 0.1€, there is an addition of 0.01€ to it for wind.

The second example investigates optimal pricing. Buying electricity means losing wealth, so at a given price of electricity, there is a utility loss for each kWh due to the decreased wealth. The decrease may be compensated by the increase in utility gained by the acquisition of electricity. The example looks at three actors and differentiated products that compete with each other not only in terms of price, but also in terms of what is being offered.

The examples are simple, to increase readability, but can be easily extended to cover more complex situations in order to further validate the proposed approach.

III. Theory and Related Work

Activity system [15], *e³value* [7], *VDML* [17], *REA* [6], *RCOV* [2], *The BM concept* [10], *Entrepreneur's BM* [16], *The social BM* [22], *The BM guide* [14], *4C* [21], *Internet BM* [15], and *BMO* [19] are all business model frameworks. In this paper we use e³value for business models because of its higher level of formality and because it is suitable for capturing network effects regarding value propagation. More information on e³value is available in [8] and [9]. The present contribution also builds on utility theory, further presented in [4], [12] and [13]. Due to space limitations, we refer the reader to the cited works for further information on e³value and utility theory.

Related work on representing immaterial value in the context of business models includes Gordijn [7] and Ceravolo et al. [23]. Related literature on the use of utility in decision making processes include Tapiero [25], Kasanen and Trigeorgis [26], Ortega and Escudero [27], Hayashida et al. [28] and Keeney and Winterfeldt [24].

IV. Extending e³value with Utility Based Analysis

This section demonstrates our approach by means of the two examples. They also serve as a proof of concept that e³value can be extended with utility theory. Our first example looks into achievement of objectives, while the second one explores optimal pricing of products in a competitive situation.

A. Example 1: Basic approach

We start with the utility analysis of our e³value baseline model. First we define an objective for each involved actor - the group of households and the electricity retailer. The objective for the households in this scenario is to heat the apartments in an environmentally sustainable fashion at as low cost as possible. The objective for the electricity retailer is to sell electricity profitably and responsibly. Based on these objectives we choose measurable attributes that represent them best. The chosen attributes need to be in accordance with the value objects that we have in our e³value model, but instead of economic value we use attribute-specific units of measurement.

The three attributes in our first example are electricity, money and greenhouse gases (GHGs). The price of electricity is measured in monetary units €, GHGs are measured in CO_2 kg, and electricity is measured in kWh. The CO_2 emission per 1 kWh is assumed to be 100 g. [30].

The data for the utility analysis should be gathered from the decision maker responsible for a related actor. We need a utility assessment for each attribute, and a utility function (and assessed scalar constants) for each actor in the e³value model. Our approach is based on the technique of utility assessment described in [13].

An actor's attitude towards an attribute is shown as a utility curve. The utility curves and estimates of scaling constants are based on the authors' estimations. In our example, we have assumed the values for educational purposes. In real life situations, utility curves for each attribute are obtained by eliciting the actor's preferences. For example, one would have to ask the household to assess the least preferred outcome, the most preferred outcome and two points in-between.

We assume that all the used attributes in this example are preference and utility independent (mutually), but not additive independent, and use the multiplicative utility function to get an approximate result [5].

The first utility curve (Figure 1) is for the household's electricity consumption in kWh. According to the figure a household prefers to have 5000 kWh of electricity per year ($u_{el} = 1$) and is less happy for a lower amount. The reasoning behind this is that based on the given data, a single household would need 3850 kWh electricity only for heating during a year. This curve and other curves are assumed to be valid for the whole group of households.

The second utility curve (Figure 2) shows how much a household is willing to spend on electricity during a year. According to the figure, the household is the happiest if it does not have to spend anything, and it is not willing to spend more than 1500 €/year on electricity ($u_{€Spent} = 0$).

The third utility curve (Figure 3) shows the households' acceptance of greenhouse gas production, which in our case means the production of CO_2. Our households are environment conscious and, therefore, averse to the production of GHGs. In our example 0 kg of CO_2 is the ideal situation, ($u_{GHG} = 1$), while 500 kg in a year is unacceptable ($u_{GHG} = 0$).

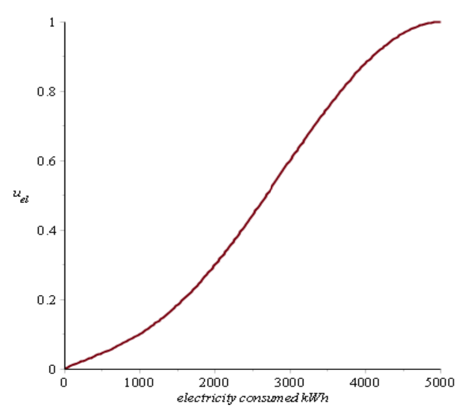

Figure 1. Utility curve for the household electricity consumption, u_{el} (kWh)

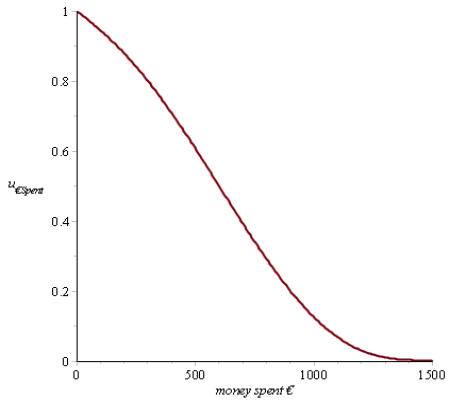

Figure 2. Utility curve for the acceptance of loss of money, $u_{€Spent}$ (€)

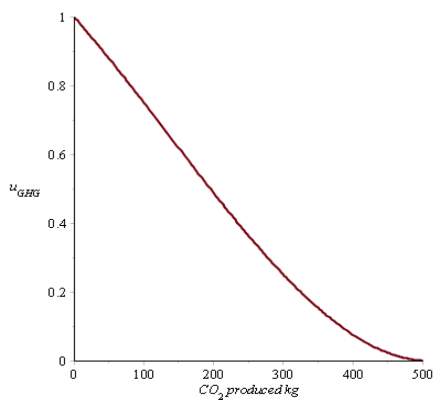

Figure 3. Utility curve for greenhouse gas production, u_{GHG} (kg)

The household then assesses each scaling constant k_i. The scaling constants are weights that determine the importance of attributes in relation to each other in the household's equation, and are collected from the actors. In this example we assume $k_{el} = 0.1$, $k_{€Spent} = 0.1$ and $k_{GHG} = 0.3$. With the k_i set, the scaling constant k can be calculated. For that purpose we use the formula (1) from [13] and get (2).

$$1 + k = \prod_{i=1}^{n} (1 + kk_i) \quad (1)$$

$$1 + k = (1 + 0.1k)(1 + 0.1k)(1 + 0.3k) \quad (2)$$
$$k = 5.7$$

Using formula (3) from [13] and k from (2), we construct the utility equation for the household (4) that characterizes the whole segment. The values for the attribute utilities are obtained from the utility curves for those attributes which are shown in Figures 1, 2, 3.

$$1 + ku(x) = \prod_{i=1}^{n} (1 + kk_i u_i(x_i)) \quad (3)$$

$$1 + 5.7U(X) = \quad (4)$$
$$(1 + 0.57u_{el}(kWh)) \left(1 + 0.57u_{€Spent}(€)\right) (1 + 1.71u_{GHG}(kg))$$

Next, we repeat the process for the electricity retailer. Here we have also three attributes that were chosen to correspond to the retailer's objective. The attributes are sold amount of electricity, revenue and GHGs produced. Our assumptions again lead us to the multiplicative function [5].

The utility curve for the retailer for the sold amount of electricity is shown in Figure 4. The curve shows that the retailer prefers to sell as much electricity as possible. However, because of the initial investment of setting up the business, the retailer has to reach a certain amount of sales to become profitable. Figure 5 shows the utility curve for electricity revenue and the straight line tells us that the retailer prefers to maximize sales. Figure 6 shows the utility curve for CO_2 production, and reveals that the retailer is to some extent environment conscious.

Next, the retailer assesses each scaling constant k_i that determine the weight for the utility functions of the attributes. In this example we assume $k_{el} = 0.7$, $k_{€Earned} = 0.7$ and $k_{GHG} = 0.3$. With the two k_i set, the scaling constant k can be calculated with formula (1), shown with (5).

$$1 + k = (1 + 0.7k)(1 + 0.7k)(1 + 0.3k) \quad (5)$$
$$k = -0.9$$

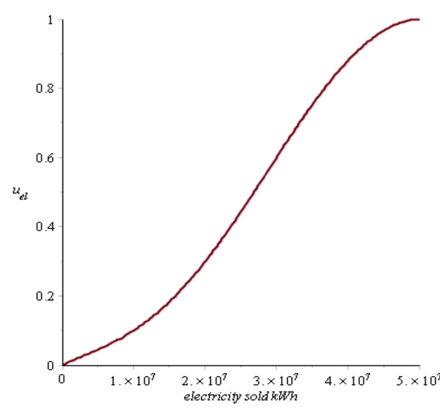

Figure 4. Utility curve for the sold amount, u_{el} (kWh)

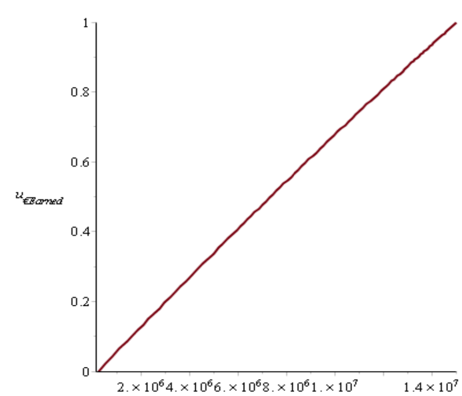

Figure 5. Utility curve for earning money, $u_{€Earned}$ (€)

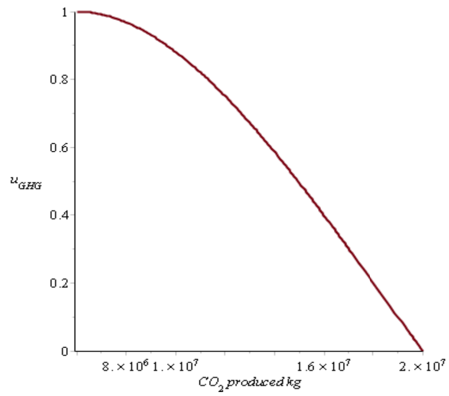

Figure 6. Utility curve for the CO_2 production, u_{GHG} (kg)

Now that we have k for the electricity retailer, we can construct the utility equation, which is shown as (6).

$$1 - 0.9U(X) = (1 - 0.63u_{el}(kWh))(1 - 0.63u_{€Earned}(€))(1 - 0.27u_{GHG}(kg)) \quad (6)$$

With the utility equations (4) for the household and (6) for the electricity retailer constructed, we can calculate the utility values for the actors in the first base model. We use the amount of goods exchanged, taken from our scenario description, as input to the equations, shown in Table 1.

TABLE 1. EXCHANGED GOODS FOR THE FIRST MODEL

	Elect. (kWh)	Money (€)	GHG (kg)
One Household	3700	370	370
Electricity retailer (for 10 000)	37 000 000	3 700 000	3 700 000
Related utility	$u_{el}(kWh)$	$u_{€Earned}(€)$	$u_{GHG}(kg)$

The utility for a single household is calculated using (4).

$$1 + 5.7U(X) = \left(1 + 0.57u_{el}(3700)\right)\left(1 + 0.57u_{€Spent}(370)\right)\left(1 + 1.71u_{GHG}(370)\right) \quad (7)$$

$$U(X) = 0.26$$

The utility for the electricity retailer is calculated using (6) in a similar way and we get (8).

$$U(X) = 0.77 \quad (8)$$

We assume that the utility value of 0.26 holds for the whole group of households.

We need more scenarios for comparison and for that we have modified our baseline e[3]value model. The methodology of how to come up with modifications for an e[3]value baseline model is described in [7]. In our case we substituted electricity mix with green wind electricity that we assume does not have CO_2 as a byproduct. The environment friendly wind electricity has a different price for the household. The value objects exchanged in the second value model are shown in Table 2.

Note that the objectives for both actors stay the same, and therefore we can use the utility graphs we obtained for the baseline model. However, if we introduce any new value objects (i.e., attributes in the utility terms), actors, or change the amount of actors in any market segments, we have to redo the utility analysis for those parts.

TABLE 2. EXCHANGED GOODS FOR THE SECOND MODEL

	Elect. (kWh)	Money (€)	GHG (kg)
One Household	3700	407	0
Electricity retailer (for 10 000)	37 000 000	4 070 000	0
Related utility	$u_{el}(kWh)$	$u_{€Earned}(€)$	$u_{GHG}(kg)$

Using (4) and (6) we get new utility values of $U(X) = 0.80$ for the household and $U(X) = 0.74$ for the retailer. The comparison of the two scenarios is shown in Table 3, where higher value means better match with the set objective.

TABLE 3. SCENARIO UTILITY COMPARISON

Actor	Scenario 1 utility	Scenario 2 utility
Household	0.26	0.80
Electricity retailer	0.77	0.74

Here we can see clearly that, given the information that we used, the households prefer scenario 2, and the electricity retailer slightly prefers scenario 1.

B. *Example 2: Optimal Pricing*

The second example explores optimal pricing under the condition of market competition with two products, mixed electricity and wind electricity. The goal for the wind electricity retailer is to enter a market and maximize its profit, while the mixed electricity retailer is already established there. The wind electricity retailer would like to know how much extra it can charge a potential customer for greenhouse free electricity, so that the customer would not lose interest. The household's utility curve is used to find out the best price. The technique shown here can be used for *n* actors and *m* of value exchanges.

We start by looking at the objectives and the attributes. The objective for the households is to get electricity without spending too much money and produce a minimum amount of greenhouse gases. The objective for the wind electricity retailer is to sell maximum amount of electricity at the highest price. We choose three attributes, which are electricity, greenhouse gases, and money. We assume that there are 10 000×70 m^2 households, with the heating need of 55 kWh/m^2/year. As this example is not about creating utility curves for actors, we reuse the ones from the previous example (see Figure 1, Figure 2 , and Figure 3).

For this analysis we are only interested in the household's utility function, and we assume that the multiplicative function is suitable. We also assume that the household assigned the following weights, which have been chosen to be different from the previous example, $k_{electricity} = 0.1$, $k_{money} = 0.1$ and $k_{GHG} = 0.01$, to the multiplicative utility function. We find the household's scalar constant k using formula (1) as shown in (9).

$$\begin{aligned} 1 + k &= (1 + 0.1k)^2 + (1 + 0.01k) \\ k &= 47.24 \end{aligned} \tag{9}$$

The new weight k and formula (3) are used to construct the household's utility function and we get (10).

$$1 + 47.24U(X) = (1 + 4.72u_{el}(kWh))(1 + 4.72u_{€Spent}(€))(1 + 0.47u_{GHG}(kg)) \tag{10}$$

Next we calculate how happy the household would be to buy electricity at a certain price. If we assume that the household maximizes its utility at all times, we get the households utility function for buying wind electricity. The graphical representation of the function for buying wind electricity, which doesn't produce any GHGs ($CO_2 = 0\ kg$), is shown in Figure 7.

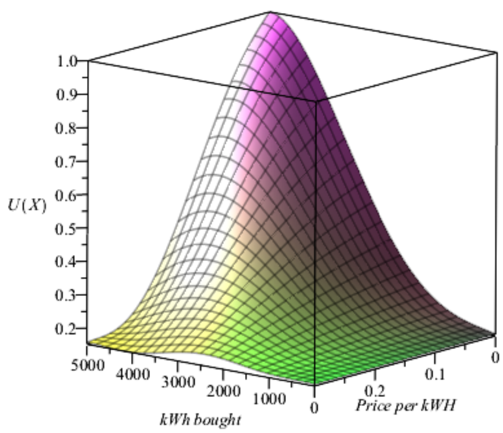

Figure 7. Household's utility function for buying wind electricity.

The next step is to derive the purchase preferences of the product. We use (11) to find the optimal points between utility, price and GHGs of electricity, where $u_{amountCost}$ stands for (10) where ($CO_2 = 0\ kg$).

$$u_{amountCost} \frac{d}{d_{kWh}} = 0 \tag{11}$$

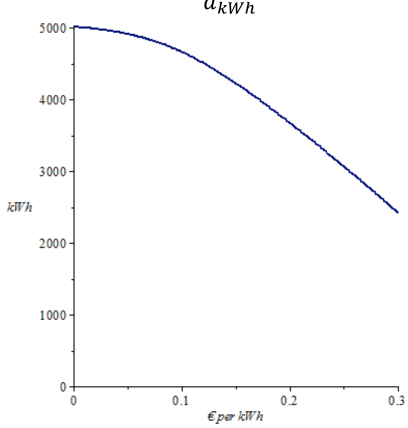

Figure 8. Household's electricity purchase preferences.

The results of the calculations are shown in Figure 8. Here we can see how much wind electricity the household would like to purchase, given the price range of 0 to 0.3€. The figure shows us that at 0€ price the household would happily purchase 5000 kWh, but as the price rises, the consumption will fall.

The next step in our analysis is to calculate the profit for the retailer using function (12), which we call the profit function. Here we assume the production cost for wind electricity to be 0.03€.

$$profit = amountSold * (price - productionCost) \tag{12}$$

The results of the profit calculation are shown in Figure 9.

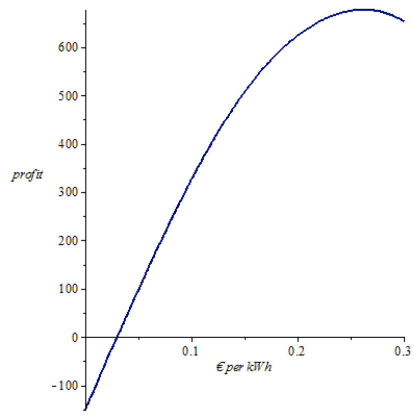

Figure 9. Retailer profit.

The optimal price is determined by solving (13).

$$profit \frac{d}{d€} = 0 \tag{13}$$

The calculation shows that the optimal price for the wind electricity is 0.26€. If the price is applied, the household would buy 2943 kWh wind electricity, which would bring the retailer a profit of 765€.

Augmenting utility theory to e3value, thus allows the identification of preferable scenarios as well as calculation of optimal pricing schemes for the involved actors.

V. Conclusion

According to one of the most highly cited books in business sciences, Michael Porter's Competitive Advantage [31], "The fundamental basis of above-average performance in the long run is sustainable competitive advantage. Though a firm can have a myriad of strengths and weaknesses vis-à-vis its competitors, there are two basic types of competitive advantage a firm can possess: low cost or differentiation. The significance of any strength or weakness a firm possesses is ultimately a function of its impact on relative cost or differentiation."

Another way to express this is to point out that whether a given business model is successful or not is thus completely dependent on the price that consumers are willing to pay for the offering. This price, in turn, is based on the relative value of the offering, i.e., the price depends not only on the absolute value as perceived by the customer, but also on the value and price of the competition. If there is no difference in perceived value (i.e. no differentiation), then there is no base for a higher price than the competition, so the remaining competitive advantage is low cost. But in order to reason about prices, and thus about business model viability, there is a need to understand the perceived customer value of the offering as compared to competing offers. In particular, it is important to understand the uniqueness of the value offering. If there is perfect substitutability between the offering and the competition, then the price cannot exceed that of the competition. The more unique the offering, the greater the difference in pricing can be.

In existing business model frameworks, such as e^3value and Osterwalder's Business Model Canvas, there is little support for reasoning about these issues. e^3value allows the modeler to specify the perceived customer value of a product in dollars and cents, but there is no way to determine the plausibility of that estimate. However, that estimate is the linchpin of the business model.

In this paper, we introduce utility theory to address this issue. An actor's joint utility function specifies how much value the actor attaches to a given product or service's different qualities. In the paper's running example, the value of electricity, the value of (not emitting) GHGs, and even the value of money are such qualities. Competing value offerings map to different points on the customer utility function, since they provide certain quantities of each quality. Since the customer can be expected to maximize her utility, her choices between offerings can be predicted. Thus, given the proposed utility extension, it is possible to quantitatively reason about the relative customer value of a business' offering compared to the offerings of the competition. This, in turn, allows the optimization of price, that key ingredient in any business model.

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