

## Conjoint analysis of treatment preference

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### ABSTRACT

Treatments are often examined for their efficacy, tolerability, effects on quality of life and cost effectiveness. No regimen is likely to have all the attributes that patients would ideally like. Therefore, it is crucial for health care industry to evaluate the patient's relative importance for each of the treatment features and their preferences for alternative treatment concepts.

Conjoint analysis is a popular marketing research technique used to analyse product preference data and to simulate consumer choice. Application of this method in health care industry has increased rapidly in the past decade. Among other things it is used in trading off desirable attributes (e.g.: high effectiveness) against undesirable ones (e.g.: cost) and describing which ones are the most important in determining the patient preferences for one regimen over another. In this paper, conjoint technique was applied to analyse patient preferences for various treatment alternatives. As consequence, allows in conclusion to answer to question: *'How much are patients willing to pay for a given profile of treatment?'*

### INTRODUCTION

Patients' needs and preferences are essential to high quality medical care. In recent years they started to play more and more significant role in the health care industry as the happier the patient is, the more is willing to pay for service.

The purpose of this paper is to evaluate, using conjoint analysis, patients' preferences for different alternatives of treatment, including efficacy, safety, treatment characteristics and costs. In creation of treatment profiles (also further called in this paper: products, objects; they should be understand as combination of features/ attributes) characteristics as pain intensity, severity of medication side effect, treatment cost, location of health care service and frequency of treatment therapy are included. No treatment regimen have all attributes that patient would ideally like. Given treatment profile will be desirable if for example is highly effective (small side effect / small pain) and undesirable if expensive (high cost). Conjoint analysis provides a method of trading off preferred characteristics against unpreferred one, and assessing which aspects are the most important in determining the patient's preferences for one treatment regimen over another.

### RELATED WORKS

Over the last 60 years, market researchers have developed conjoint analysis to understand customer preferences and costs. Conjoint methods were built based on the original research from 1964 of mathematical psychologist Luce and statistician Tukey [1]. Their theoretical contribution was used by a number of psychometricians: Carroll [2], Kruskal [3] and Young [4] in studies developed a variety of nonmetric models for estimating part-worth (attribute level values) utilities from responders' preference orderings across multi-attributed determinants, such as descriptions of products or services.

Although conjoint theory was mainly developed in economic and marketing sciences, it became more and more popular also in other areas. Stated preference methods are particularly useful for describing preferences for products and services if no markets exist or if market choices are influenced by institutional factors and regulatory as in health and medicine [5]. In clinical researches conjoint analysis has been applied successfully to measuring preferences for a wide variety of health fields as: cancer treatments [6], HIV testing [7] and treatment [8], dermatology services [9], asthma medications [10], genetic counselling [11], weight-loss programs [12], insulin therapy in type 2 diabetes [13], diabetes prevention programs [14], colorectal cancer screening [15], and treatments for Alzheimer's disease [16].

### PREFERENCES AND UTILITY FUNCTION

Economic model of consumer behaviour is very simple: people choose the best things they can afford. The main assumption of this theory is rationality of subjects - their decisions and choices are optimal in existing conditions (taking into account their budget constraints).

Utility theory is the conceptual and metrological basis used to describe behaviour of people in the market. According to this idea consumers, making decisions about buying products and services, maximize their utility function.

**Utility function** (target function which is maximized within established constraints) is subjectively felt by each person satisfaction from realization of given structure of consumption (also further called basket, bundles of goods). Utility function  $U_i = f_i(z_1, \dots, z_k)$  where  $f_i$  denotes association between variables for i-th consumer and states the basis for describing **relation of preference** ( $\succ$ ) or **indifference** ( $\approx$ ) between baskets of items in

interest defined by variables  $\{z_1, \dots, z_k\}$ . A utility function is a way of assigning a number to every possible consumption bundle such that more preferred baskets have assigned larger numbers than less preferred one. A basket  $(x_1, x_2, \dots, x_k)$  is preferred to a basket  $(y_1, y_2, \dots, y_k)$  if and only if the utility of  $(x_1, x_2, \dots, x_k)$  is larger than the utility of  $(y_1, y_2, \dots, y_k)$ , in symbols:

$$(x_1, x_2, \dots, x_k) \succ (y_1, y_2, \dots, y_k) \Leftrightarrow U(x_1, x_2, \dots, x_k) > U(y_1, y_2, \dots, y_k)$$

The only important property of a utility assignment is that how it orders the bundles of goods. The value of the utility function ranks the different consumption baskets of products and services from the most to the least preferable according to consumers' preferences. The size of the utility difference between any two consumption bundles doesn't matter.

## PREFERENCES MEASURE

### CONCEPTUAL FRAMEWORK OF CONJOINT ANALYSIS

Hair, Black, Babin and Anderson [17] defined conjoint analysis as 'a *multivariate technique developed specifically to understand how responders develop preferences for objects (products, services, or ideas)*'. This methodology is used to measure customers' preference structure basing on following general model:

$$U_{ix} = f_x(u_{1(ix)}, u_{2(ix)}, \dots, u_{k(ix)})$$

where:

$U_{ix}$  - total utility of i-th profile for x-th consumer (responder, purchaser),

$f_x(\cdot)$  - analytic form of preference function of x-th responder,

$u_{j(ix)}$  - utility of i-th profile on the grounds of j-th variable perceived by x-th responder.

Values of dependent variable, called total utilities of profiles, are results of direct responders' ratings and reflect their preferences. Values of independent variables represent levels of attributes of rated objects (profiles). The way in which they are perceived by responder has impact on the given profile grade, thus also on its total utility. Conjoint procedure drives to decomposition of total utility into partial utilities – connected with the particular levels of independent variables. Total utilities refer to profiles, while partial utilities to levels of attributes characterized defined profiles. There are two main models used to describe dependence between total and partial utilities:

- additive model (main effects model – on which this paper will focus on),
- model including interactions between independent variables (main effect model with interactions).

The choice of rule describing the relation between variables determine the number of profiles that have to be rated by responder and estimation method, which is used to compute partial utility. Additive model requires the smaller number of profiles that have to be graded.

### THEORETICAL BACKGROUND OF CONJOINT ANALYSIS – MAIN EFFECT MODEL

Conjoint analysis is main effects analysis of covariance with an ordinal dependent variable. It is based on following assumptions:

- the product is a set of attributes,
- utility of a product is a function of the utility of attributes,
- utility function is indicator of consumer behaviour.

In metric conjoint analysis, additive simple main effect ANCOVA model with attributes of the products/ services as independent variables and grades of products/ services utility as dependent variable is defined in the following way:

$$\hat{U}_{ix} = \mu_x + \sum_{j=1}^m \sum_{p=1}^{m_j} u_{jp(x)} \cdot x_{jp(i)} + \varepsilon_{ix}$$

where:

$\hat{U}_{ix}$  - estimated total utility of i-th profile for x-th consumer,

$\mu_x$  - intercept,

$u_{jp(x)}$  - estimated coefficient (part-worth utility) of p-th level of j-th independent variable for x-th responder,

$x_{jp(i)}$  - artificial variable representing levels of explanatory variable. In case of zero-one coding:

$$x_{jp(i)} = \begin{cases} 1, & \text{if } p\text{-th level of } j\text{-th variable appearing in } i\text{-th profile,} \\ 0, & \text{otherwise.} \end{cases}$$

$\varepsilon_{ix}$  - error term,

$j = 1, \dots, m$  - number of explanatory variables (attributes),

$m_j$  - number of levels of j-th variable.

Values of assessments of products are decomposed based on qualitative attributes of the products/ services. In the next step part-worth utility value is calculated for each level of each attribute. The target is to assign utilities such that the rank ordering of the sums of each product's set of utilities is the same as the original rank ordering or violates that ordering as little as possible.

Model estimation method depends on assumed preference structure (the type of utility function) - the type of relation between values of part-worth utilities of profiles presented to responders for rating and values of levels of explanatory variables describing those objects (profiles). Following types of relations are usually listed:

- vector model (linear),
- ideal point/ anti-ideal point model (quadratic),
- part-worth model (piecewise linear) (it will be used in this paper and will be described below),
- mixed model.

The part-worth model assumes that utility curve is created by a set of straight lines that connect the point estimates of the utilities for the attribute levels (in other words, represents attributes utility by a piecewise linear curve):

$$\tilde{U}_{ix} = \sum_{j=1}^m \sum_{l_j=1}^{L_j} w_{jl_j} \cdot f_{l_j}(y_{ji})$$

where:

$\tilde{U}_{ix}$  - preference of the x-th responder for i-th profile,

$f_{l_j}(\cdot)$  - the function representing the part-worth value of each of the  $L_j$ -th levels of j-th variable,

$w_{jl_j}$  - individual weight of  $L_j$ -th level of j-th variable (attribute) for x-th responder.

## STEPS IN CONJOINT ANALYSIS FOR TREATMENT MARKET RESEARCH

Following steps to be taken in applying conjoint analysis for treatment market research:

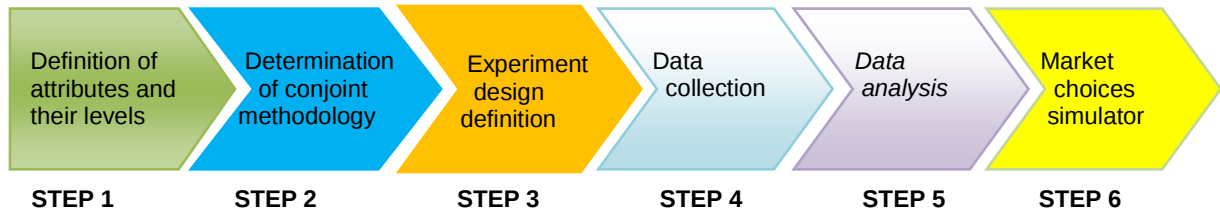


Figure 1. Conjoint research process

### STEP 1: Definition of attributes and their levels

Define treatment attributes or features that are the most important in the problem. Select ones that play crucial role in determining the patient's preferences for one treatment regimen over another. Next establish their levels that will be taken into account in analysis.

### STEP 2: Determination of conjoint methodology

Choose the conjoint methodology which will be the most appropriate in the research. Choice and preference based conjoint methodologies that are the most often used. Researchers usually focus only on the main effects and each attribute utilities. However, if attributes such as price and brand are considered, potential interactions between those attributes should also be taken into account and analysed.

### STEP 3: Experiment design definition

Define treatment profiles as a combination of attributes options. Given set of attributes combinations create specific treatment profile. Decide whether all possible profiles (full profile method) will be presented to patients or not. Choose the form in which the profiles will be presented to the responders (most popular are: verbal presentation, paragraph description or pictorial presentation). Decide whether and how patients will be aggregated. There are three possibilities: to use individual responses, to pool all responses into a single utility function, to define segments of responders with similar preferences.

### STEP 4: Data collection

Patients rank presented to them set of treatment profiles according to some overall criterion, such as: preference, acceptability or likelihood of purchase.

**STEP 5: Data analysis**

Select the technique that to be used to analyse collected data. The simplest model that can be used to express the utilities of the various attributes is part-worth model (it is used in this paper). There are also vector (linear) models and ideal-point (quadratic) models, etc.

Calculate the utilities for each responder or for groups of responders. Part-worth utilities are estimated for the all levels of attributes. Each combination of part-worth utilities equals the total utility of specific profile.

**STEP 6: Market choices simulator**

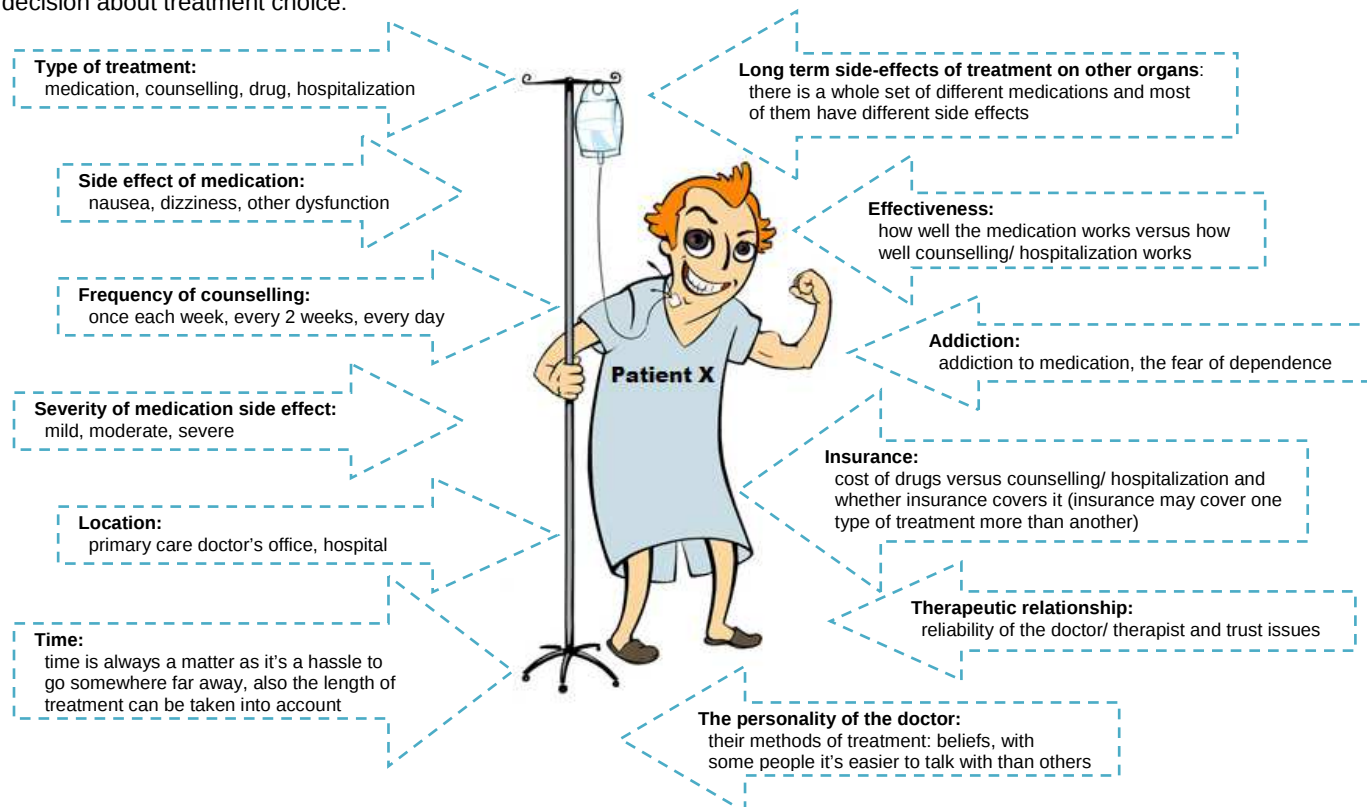
Based on determined part-worth utilities for each patient, utility value for each of the objects defined as part of the choice simulation is computed. Simulator models as first choice model, average probability model or logit model are most commonly used. Such models not only estimate the responders object of choice, but also allow to predict the impact of changes in existing product/ service and the introduction of new product/ service on the market.

In the empirical part of this paper data collection step is discounted and patients' preferences are generated randomly. All analysis are performed in SAS ® software.

**WHICH TREATMENT WOULD YOU CHOOSE?**

According to economic theories utility of given product/ service is compatible with the willingness to pay for the given feature and is considered to be sufficient circumstance to make decisions which features to include in object and which not. Treatment profile consists of combination of features. Preferences among treatment alternatives depend on the relative importance of those attributes.

On the one hand, there is a large and differential number of aspects that patient can take into account when make decision about treatment choice:



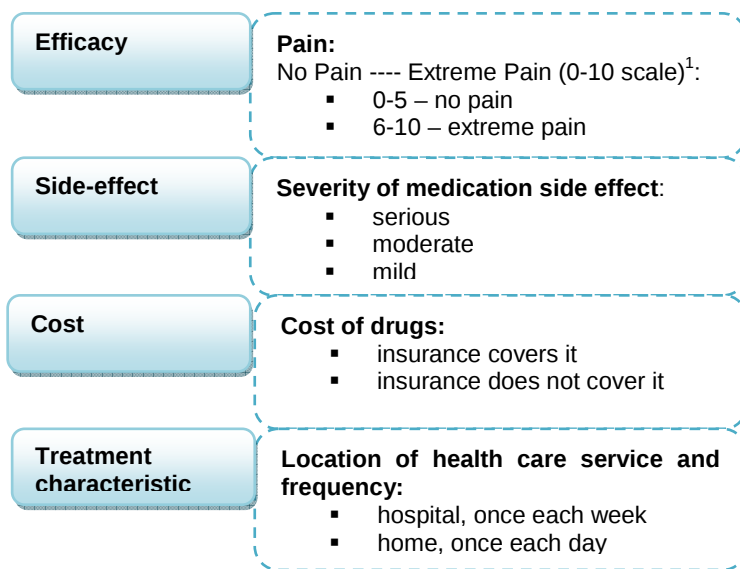
**Figure 2.** Features and levels that Patient X can take into account when make decisions about treatment choice

On the other hand, it is documented in behavioural literature, that informative capacity limitations characterize human's perception – making decision subject takes into account at least 4-5 features/ attributes/ aspects.

**UTILITY FACTORS AND THEIR LEVEL SELECTION**

It is impossible for patient to make decision about treatment choice basing on all presented above features. Appropriate selection of attributes/ features that play crucial role for patients and additionally which will sufficiently differentiate various aspects of treatment alternatives is important research problem in this type of analysis as can significantly affect study conclusions. Referring to related literature, following 4 characteristics (that very often are considered) can be pointed: type of treatment, treatment cost, location of health care service and side effect.

Those aspects will be taken into account in further considerations in this paper. Their levels are presented in Figure 3.



<sup>1</sup> To reduce number of alternatives, two levels of this variable were determined.

**Figure 3.** Considered treatment aspects and their levels

#### TREATMENT PROFILES CREATION– FULL PROFILE METHOD

The simplest experimental design is that, which consists of all possible combinations of the attributes levels. In full profile analysis, responder knows the full description (have knowledge about all factors) of the compared treatments. With four aspects varying, at two levels three and three levels one, there are  $2 \times 2 \times 2 \times 3 = 24$  possible combinations.

List of all possible profiles can be created using PROC PLAN procedure:

```
proc plan ordered;
  factors efficacy=2 side_effect=3 cost=2 characteristics=2 / noprint;
  output out=treatment_profiles
    efficacy      cvals = ('no pain' 'extreme pain')
    side_effect   cvals = ('serious' 'moderate' 'mild')
    cost          cvals = ('insurance cover it' 'insurance does not cover it')
    characteristics cvals = ('hospital, once each week' 'home, once each day');
run;quit;
```

with result presented in four first columns of Table 1 below.

In next step, generated treatment profiles should be presented to responders for rating from the most to the least preferable. It is possible only if combination of all available levels of analysed features is relatively small. If number of attributes is large – for responder appears practical problem as it is too difficult for him/ her to rate all feasible combinations. This is a main reason for choosing fractional-factorial designs, which based on fewer levels combination than full profile design.

#### NOTE ABOUT SELECTING PROFILES MORE EFFICIENTLY

In full profile method patient has to rate 24 possible combinations of feature levels. But what if his endure allows him to rate maximally 15 profiles?

To reduce the responder task and select profiles more efficiently one of the most common experimental designs - known as an orthogonal fractional factorial design (orthogonal design) - can be used. It can be created using PROC OPTEX.

In this approach, the levels of the attributes are chosen such that, for each pair of features (denoted as A and B), the high level A appears equally often in profiles that have a high level B as in profiles that have a low level of B, and vice versa. The main assumption of this sampling scheme states that all attributes of product/ service impact on general mark of utility in additive way. It means that between attributes no interactions should exist - with such designs just main effects of each feature can be estimated.

Number of designs can be controlled using n option in PROC OPTEX. N=SATURATED allows to find a design with minimal number of profiles – equal to the number of parameters in the model.

```
proc optex data=treatment_profiles coding=orth;
  class efficacy side_effect cost characteristics;
  model efficacy side_effect cost characteristics; generate n=15;
  output out=treatment_plan_orth;
run;quit;
```

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### METRIC CONJOINT ANALYSIS FOR PATIENT X

The problem of describing individual utility will be analysed on example of Patient X (presented in Figure 2). The interviewees patient rated presented to him treatment profiles on a 1 to 24 scale where 1 means low preference and 24 means high preference. His assessments for all different treatment features levels combination (received using PROC PLAN procedure) are summarized in below Table 1:

| Efficacy     | Side effect | Cost                        | Characteristic           | Patient X rates |
|--------------|-------------|-----------------------------|--------------------------|-----------------|
| no pain      | serious     | insurance cover it          | hospital, once each week | 7               |
| no pain      | serious     | insurance cover it          | home, once each day      | 8               |
| no pain      | serious     | insurance does not cover it | hospital, once each week | 5               |
| no pain      | serious     | insurance does not cover it | home, once each day      | 6               |
| no pain      | moderate    | insurance cover it          | hospital, once each week | 19              |
| no pain      | moderate    | insurance cover it          | home, once each day      | 20              |
| no pain      | moderate    | insurance does not cover it | hospital, once each week | 16              |
| no pain      | moderate    | insurance does not cover it | home, once each day      | 18              |
| no pain      | mild        | insurance cover it          | hospital, once each week | 23              |
| no pain      | mild        | insurance cover it          | home, once each day      | 24              |
| no pain      | mild        | insurance does not cover it | hospital, once each week | 21              |
| no pain      | mild        | insurance does not cover it | home, once each day      | 22              |
| extreme pain | serious     | insurance cover it          | hospital, once each week | 3               |
| extreme pain | serious     | insurance cover it          | home, once each day      | 4               |
| extreme pain | serious     | insurance does not cover it | hospital, once each week | 1               |
| extreme pain | serious     | insurance does not cover it | home, once each day      | 2               |
| extreme pain | moderate    | insurance cover it          | hospital, once each week | 11              |
| extreme pain | moderate    | insurance cover it          | home, once each day      | 12              |
| extreme pain | moderate    | insurance does not cover it | hospital, once each week | 9               |
| extreme pain | moderate    | insurance does not cover it | home, once each day      | 10              |
| extreme pain | mild        | insurance cover it          | hospital, once each week | 15              |
| extreme pain | mild        | insurance cover it          | home, once each day      | 17              |
| extreme pain | mild        | insurance does not cover it | hospital, once each week | 13              |
| extreme pain | mild        | insurance does not cover it | home, once each day      | 14              |

**Table 1.** Treatment profiles created using PROC PLAN and theirs rates provided by Patient X

PROC TRANSREG is used to perform a metric conjoint analysis and determine the importance of each attribute and the values of part-worth utility for each level of each attribute:

```
proc transreg data=treatment_preferences
    outtest=treatment_utility
    utilities separators=",";
    model identity(preference) =
        class(efficacy side_effect cost characteristics / zero=sum);
run;
```

which gives the output:

| Univariate ANOVA Table Based on the Usual Degrees of Freedom |    |                |             |         |        |
|--------------------------------------------------------------|----|----------------|-------------|---------|--------|
| Source                                                       | DF | Sum of Squares | Mean Square | F Value | Pr > F |
| Model                                                        | 5  | 1130.083       | 226.0167    | 204.27  | <.0001 |
| Error                                                        | 18 | 19.917         | 1.1065      |         |        |
| Corrected Total                                              | 23 | 1150.000       |             |         |        |
| Root MSE                                                     |    | 1.05189        | R-Square    | 0.9827  |        |
| Dependent Mean                                               |    | 12.50000       | Adj R-Sq    | 0.9779  |        |
| Coeff Var                                                    |    | 8.41515        |             |         |        |

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Utilities Table Based on the Usual Degrees of Freedom

| Label                                     | Utility | Standard Error | Importance (% Utility Range) |
|-------------------------------------------|---------|----------------|------------------------------|
| Intercept                                 | 12.5000 | 0.21472        |                              |
| efficacy, extreme pain                    | -3.2500 | 0.21472        | 27.130                       |
| efficacy, no pain                         | 3.2500  | 0.21472        |                              |
| side_effect, mild                         | 6.1250  | 0.30366        | 58.957                       |
| side_effect, moderate                     | 1.8750  | 0.30366        |                              |
| side_effect, serious                      | -8.0000 | 0.30366        |                              |
| cost, insurance cover it                  | 1.0833  | 0.21472        | 9.043                        |
| cost, insurance does not cover it         | -1.0833 | 0.21472        |                              |
| characteristics, home, once each day      | 0.5833  | 0.21472        | 4.870                        |
| characteristics, hospital, once each week | -0.5833 | 0.21472        |                              |

### Part-worth utility

Above SAS output shows the part-worth utilities in utility column (in Utilities Table Based on the Usual Degrees of Freedom panel). Results reflect the most and the least preferred levels of the considered attributes for Patient X - levels with positive values of utility are preferred over those with negative. No pain (part-worth utility = 3.2500) is preferred over pain (-3.2500), cost covered by insurance (1.0833) over paying for treatment (-1.0833), taking drug in home (0.5833) over taking drug in hospital (-0.5833), mild side-effect (6.1250) over moderate (1.8750) and those over serious (-8.0000). Preferences of Patient X seem to be consistent with his rates and most of the real patients' priorities.

The predicted utility of conjoint analysis model for the preference for treatment with efficacy level i, side-effect j, cost k and characteristic p is the sum of the intercept and the part-worth utilities of attributes:

$$\hat{U}_{ijkp} = \hat{\mu} + \hat{u}_i + \hat{u}_j + \hat{u}_k + \hat{u}_p, \quad i, k, p=1,2; j=1,2,3;$$

For the most preferred treatment (no pain, mild side-effect, cost covered by insurance and drug taken every day in home), the predicted utility and actual preference value is:

$$\hat{U}_{1312} = 12.5 + 3.25 + 6.125 + 1.0833 + 0.5833 = 23.5416$$

For the least preferred treatment (extreme pain, serious side-effect, cost not covered by insurance and drug taken every week in hospital), the predicted utility and actual preference values is:

$$\hat{U}_{2121} = 12.5 - 3.25 - 8 - 1.0833 - 0.5833 = -0.4166$$

### Importance value

The importance value is computed from the part-worth utilities for each feature of treatment as range for each factor divided by the sum of all ranges and multiplied by 100:

$$I_a = \frac{\max \hat{U}_{ay} - \min \hat{U}_{ay}}{\sum_{a \in A} (\max \hat{U}_{ay} - \min \hat{U}_{ay})} \cdot 100\%$$

where:

$I_a$  - importance value for feature a,  $a \in A$ ,  $A = \{\text{efficacy, side\_effect, cost, characteristics}\}$ ,

$\hat{U}_{ay}$  - part-worth utility for feature a with level y.

In determining Patient X preferences the most important treatment attribute is side-effect with the importance value calculated in the following way and equal 58.957:

$$\begin{aligned} I_{\text{side-effect}} &= \frac{(6.125 - -8)}{(3.25 - -3.25) + (6.125 - -8) + (1.0833 - -1.0833) + (0.5833 - -0.5833)} \cdot 100\% \\ &= \frac{14.125}{23.9582} \cdot 100\% = 58.95685\% \approx 58.957\% \end{aligned}$$

Instead of metric conjoint analysis nonmetric conjoint analysis can be used. Nonmetric conjoint analysis iteratively derives the monotonic transformation of the preferences (instead of identity transformation option in model statement monotone to be used). The size of differences in part-worth utilities and importance values received from both methods will depend from the transformation. If it is nearly linear, just slight differences will be obtained.

## DESCRIBING MARKET PREFERENCES

For purposes of further analysis additional 9 patients were asked for preparing map of their assessments for considered 24 treatment profiles (their rates were generated randomly using ranuni(0) function and PROC SORT procedure). Their grades are summarized in below Table 2.

Moreover, it is assumed that interviewed 10 subjects are representative sample of considered artificial market.

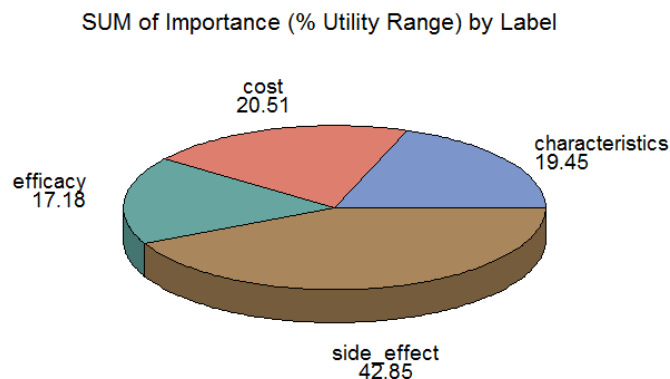
| Efficacy            | Side effect    | Cost                        | Characteristic             | Rates of Patient: |           |           |           |           |           |           |           |           |          |
|---------------------|----------------|-----------------------------|----------------------------|-------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
|                     |                |                             |                            | X                 | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9        |
| no pain             | serious        | insurance cover it          | hospital, once each week   | 7                 | 6         | 6         | 20        | 19        | 15        | 14        | 22        | 21        | 22       |
| no pain             | serious        | insurance cover it          | home, once each day        | 8                 | 22        | 3         | 9         | 9         | 18        | 15        | 9         | 1         | 24       |
| no pain             | serious        | insurance does not cover it | hospital, once each week   | 5                 | 3         | 19        | 4         | 23        | 12        | 10        | 19        | 9         | 20       |
| no pain             | serious        | insurance does not cover it | home, once each day        | 6                 | 4         | 4         | 23        | 16        | 13        | 16        | 4         | 8         | 12       |
| no pain             | moderate       | insurance cover it          | hospital, once each week   | 19                | 11        | 20        | 1         | 22        | 24        | 23        | 17        | 6         | 6        |
| no pain             | moderate       | insurance cover it          | home, once each day        | 20                | 17        | 7         | 7         | 6         | 10        | 2         | 21        | 22        | 16       |
| no pain             | moderate       | insurance does not cover it | hospital, once each week   | 16                | 14        | 15        | 2         | 7         | 5         | 11        | 18        | 20        | 19       |
| no pain             | moderate       | insurance does not cover it | home, once each day        | 18                | 20        | 14        | 21        | 13        | 1         | 6         | 5         | 19        | 13       |
| no pain             | mild           | insurance cover it          | hospital, once each week   | 23                | 7         | 24        | 16        | 2         | 8         | 24        | 15        | 3         | 21       |
| no pain             | mild           | insurance cover it          | home, once each day        | 24                | 18        | 2         | 11        | 8         | 9         | 19        | 11        | 17        | 8        |
| no pain             | mild           | insurance does not cover it | hospital, once each week   | 21                | 19        | 17        | 10        | 5         | 7         | 12        | 2         | 15        | 11       |
| no pain             | mild           | insurance does not cover it | home, once each day        | 22                | 5         | 21        | 17        | 3         | 2         | 5         | 8         | 2         | 18       |
| extreme pain        | serious        | insurance cover it          | hospital, once each week   | 3                 | 10        | 8         | 3         | 18        | 3         | 7         | 1         | 7         | 14       |
| <b>extreme pain</b> | <b>serious</b> | <b>insurance cover it</b>   | <b>home, once each day</b> | <b>4</b>          | <b>15</b> | <b>13</b> | <b>15</b> | <b>24</b> | <b>21</b> | <b>22</b> | <b>13</b> | <b>24</b> | <b>9</b> |
| extreme pain        | serious        | insurance does not cover it | hospital, once each week   | 1                 | 2         | 22        | 19        | 10        | 23        | 17        | 7         | 11        | 17       |
| extreme pain        | serious        | insurance does not cover it | home, once each day        | 2                 | 12        | 9         | 8         | 1         | 17        | 20        | 3         | 5         | 2        |
| extreme pain        | moderate       | insurance cover it          | hospital, once each week   | 11                | 23        | 11        | 14        | 20        | 6         | 8         | 12        | 23        | 23       |
| extreme pain        | moderate       | insurance cover it          | home, once each day        | 12                | 8         | 23        | 6         | 14        | 14        | 3         | 6         | 16        | 3        |
| extreme pain        | moderate       | insurance does not cover it | hospital, once each week   | 9                 | 9         | 5         | 12        | 4         | 19        | 13        | 10        | 12        | 15       |
| extreme pain        | moderate       | insurance does not cover it | home, once each day        | 10                | 1         | 12        | 24        | 11        | 22        | 18        | 20        | 13        | 1        |
| extreme pain        | mild           | insurance cover it          | hospital, once each week   | 15                | 24        | 10        | 18        | 17        | 11        | 21        | 23        | 4         | 4        |
| extreme pain        | mild           | insurance cover it          | home, once each day        | 17                | 13        | 1         | 22        | 15        | 16        | 9         | 14        | 18        | 7        |
| extreme pain        | mild           | insurance does not cover it | hospital, once each week   | 13                | 16        | 16        | 5         | 12        | 20        | 4         | 16        | 10        | 10       |
| extreme pain        | mild           | insurance does not cover it | home, once each day        | 14                | 21        | 18        | 13        | 21        | 4         | 1         | 24        | 14        | 5        |

**Table 2.** Patients' rates of treatments profiles

Mean of randomly generated ranges of profiles indicate that in average the highest rated by market is treatment profile with extreme pain, serious side effect, treatment covered by insurance and treatment applied in home, once each day. Such preference seems to not be consistent with preferences of Patient X.

### Treatment attributes importance for the market

Preferences of each patient were analysed using PROC TRANSREG as it was shown in previous part of this paper on example of Patient X. Summary of importance of considered treatments aspects for artificial treatment market is presented in below graph (Figure 4):



**Figure 4.** Treatment attributes importance for the market

Received results draw to conclusion that the significantly most important feature in this market is side effect of the treatment (42.85%). The least - efficacy of drug treatment (17.18%). Cost of treatment (20.51%) and fact whether it is received in hospital or in home with different frequency (19.45%) seems to have approximate priority.

#### Levels of attributes importance for the market

Summary of average importance for particular levels of considered treatments aspects are presented in below graphs (Figure 5):

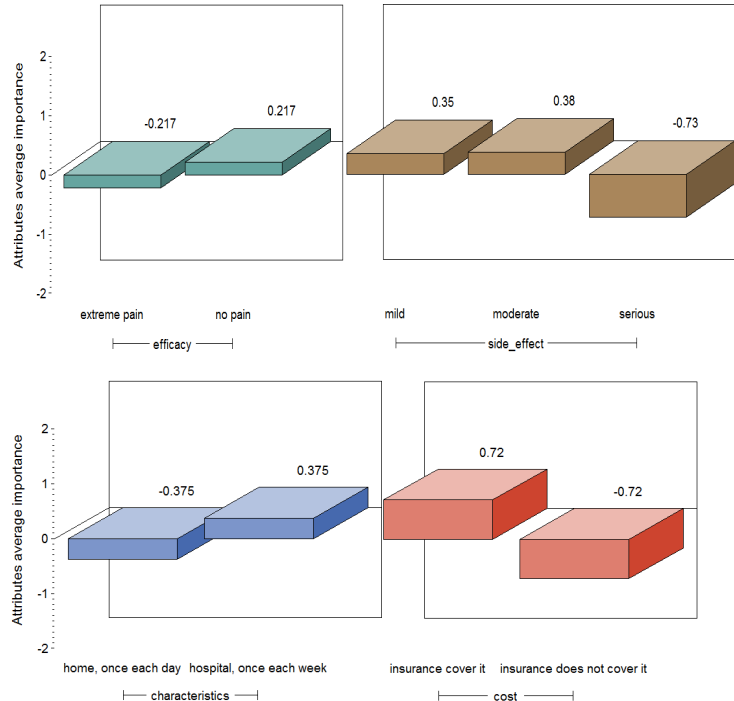


Figure 5. Mean treatment attributes levels importance for the market

#### CHOICE SIMULATION AND PREDICTION OF MARKET SHARE – MAXIMUM UTILITY MODEL

In this part of the paper the utilities from a conjoint analysis will be used to simulate patients' treatment choices and to predict market share for hypothetical product profiles. Market share is a prediction of the proportion of times that the product will be chosen and bought.

At the beginning **maximum utility model** is estimated. It assumes that each patient will always choose and buy the product/ service with the highest utility (if happen that more than one product has the same maximum utility, subject randomly choose between them with equal probability). Next, the most preferred combination (with the largest total utility) for each subject is found and probabilities with which each combination will be purchased is assigned. If maximum utility correspond just to one profile within a subject, that patient will have one probability of 1 and the rest will be equal to 0. If maximum utility correspond to two items within a subject, that patient will have two probabilities equal to 0.5 and the rest will be 0.

To get market share, in the last step, received probabilities are averaged across subjects. In this paper, two scenarios will be considered:

- All subjects will be equally weighted.
- If it is known a priori that given market segment has different impact/ demand than others, subjects can be differentially weighted in the process of market share calculation. To illustrate that, in considered example, it will be assumed that Patient X states 30% of demand for treatment service in the market.

Typical models for forecasting probability of subjects' choices or appearance of events or opportunities are logit/ probit models. The maximum utility model has the advantage over those two as of being scale-free. Any strictly monotonic transformation of each subject's utilities will produce the same market share. However, it should be pointed that this type of model has one drawback as assigning a probability of choice equal to zero for all options which don't have maximum utility (also for those that have utilities near the maximum).

Maximal utilities for all patients are summarized in Table 3. Treatment profiles corresponding to them where chosen by patients.

| Patient | Intercept | Characteristic | Cost   | Efficacy | Side effect | Utility |
|---------|-----------|----------------|--------|----------|-------------|---------|
| X       | 12.5000   | 0.5833         | 1.0833 | 3.2500   | 6.1250      | 23.5417 |
| 1       | 12.5000   | 0.5000         | 2.0000 | 0.3333   | 2.8750      | 18.2083 |
| 2       | 12.5000   | 1.9167         | 1.8333 | 0.1667   | 1.1250      | 17.5417 |

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| Patient | Intercept | Characteristic | Cost   | Efficacy | Side effect | Utility |
|---------|-----------|----------------|--------|----------|-------------|---------|
| 3       | 12.5000   | 2.1667         | 0.6667 | 0.7500   | 1.5000      | 17.5833 |
| 4       | 12.5000   | 0.7500         | 2.0000 | 1.4167   | 2.5000      | 19.1667 |
| 5       | 12.5000   | 0.2500         | 0.4167 | 2.1667   | 2.7500      | 18.0833 |
| 6       | 12.5000   | 1.1667         | 1.4167 | 0.5833   | 2.6250      | 18.2917 |
| 7       | 12.5000   | 1.0000         | 1.1667 | 0.0833   | 1.6250      | 16.3750 |
| 8       | 12.5000   | 0.7500         | 1.0000 | 0.5833   | 3.8750      | 18.7083 |
| 9       | 12.5000   | 2.6667         | 0.5833 | 3.3333   | 2.5000      | 21.5833 |

**Table 3.** Maximum utility values for each patient

Received market share can be summarized as below (Table 4):

| Efficacy            | Side effect    | Cost                        | Characteristic                  | Market share |
|---------------------|----------------|-----------------------------|---------------------------------|--------------|
| extreme pain        | mild           | insurance cover it          | home, once each day             | 10           |
| extreme pain        | mild           | insurance does not cover it | home, once each day             | 10           |
| extreme pain        | moderate       | insurance cover it          | home, once each day             | 10           |
| <b>extreme pain</b> | <b>serious</b> | <b>insurance cover it</b>   | <b>hospital, once each week</b> | <b>20</b>    |
| no pain             | mild           | insurance cover it          | home, once each day             | 10           |
| no pain             | mild           | insurance cover it          | hospital, once each week        | 10           |
| no pain             | mild           | insurance does not cover it | hospital, once each week        | 10           |
| <b>no pain</b>      | <b>serious</b> | <b>insurance cover it</b>   | <b>hospital, once each week</b> | <b>20</b>    |

**Table 4.** Market share of treatment profiles with not zero market share

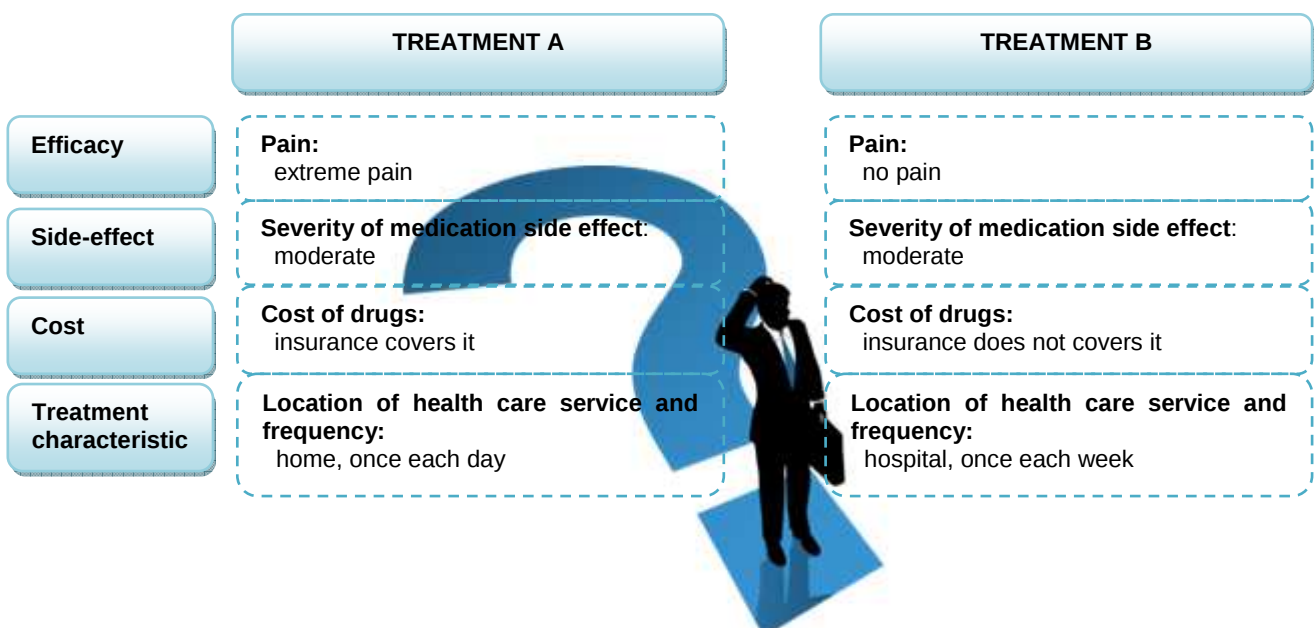
Only eight combinations of treatment aspects have an expected market share greater than zero. Six features combinations have it equals to 10%. Maximum utility model indicates that on considered market two treatment profiles have the largest market share (20%):

- treatment with extreme pain, serious side-effect, cost covered by insurance and treatment provided in hospital once a week,
- treatment with no pain, serious side-effect, cost covered by insurance and treatment provided in hospital once a week.

Thus, it is most profitable to sell services/ products characterised by such attributes combination in this market.

### WHICH TREATMENT TO BE INTRODUCED INTO THE MARKET?

The pharmaceutical company would like to introduce into considered market one from two treatments: A or B, having characteristics as described in below Figure 6:



**Figure 6.** Hypothetical treatments

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The pharmaceutical company meets the question: **Which treatment to be introduced into the market?** The answer is simple – this for which the biggest demand will be in this market. We are assuming that patients act in rational way, so the biggest demand will be for treatment that provides the patients the biggest value of utility. It has to be checked what Patient X and market would choose.

**Which treatment would Patient X (whose preferences are described above) choose if there were only those two options available?**

Predicted utilities of conjoint analysis model for Patient X for both treatments alternatives are equal respectively:

$$\hat{U}_{2212}^A = 12.5000 - 3.2500 + 1.8750 + 1.0833 + 0.5833 = 12.7916$$

$$\hat{U}_{1221}^B = 12.5000 + 3.2500 + 1.8750 - 1.0833 - 0.5833 = 15.9584$$

If Patient X acts in rational way, he will chose treatment B if only those two option are available, as it provides him greater utility than treatment A.

**Which treatment will be chosen by the market if there were only those two options available?**

| TREATMENT A                           |                 |         |           |             |         | TREATMENT B                           |         |           |             |         |  |
|---------------------------------------|-----------------|---------|-----------|-------------|---------|---------------------------------------|---------|-----------|-------------|---------|--|
| Patient                               | Characteris-tic | Cost    | Eff-icacy | Side effect | Utility | Characteris-tic                       | Cost    | Eff-icacy | Side effect | Utility |  |
| X                                     | 0.5833          | 1.0833  | -3.2500   | 1.8750      | 12.7917 | -0.5833                               | -1.0833 | 3.2500    | 1.8750      | 15.9583 |  |
| 1                                     | 0.5000          | 2.0000  | 0.3333    | 0.3750      | 15.7083 | -0.5000                               | -2.0000 | -0.3333   | 0.3750      | 10.0417 |  |
| 2                                     | -1.9167         | -1.8333 | -0.1667   | 0.8750      | 9.4583  | 1.9167                                | 1.8333  | 0.1667    | 0.8750      | 17.2917 |  |
| 3                                     | 2.1667          | -0.6667 | 0.7500    | -1.6250     | 13.1250 | -2.1667                               | 0.6667  | -0.7500   | -1.6250     | 8.6250  |  |
| 4                                     | -0.7500         | 2.0000  | 1.4167    | -0.3750     | 14.7917 | 0.7500                                | -2.0000 | -1.4167   | -0.3750     | 9.4583  |  |
| 5                                     | -0.2500         | 0.4167  | 2.1667    | 0.1250      | 14.9583 | 0.2500                                | -0.4167 | -2.1667   | 0.1250      | 10.2917 |  |
| 6                                     | -1.1667         | 1.4167  | -0.5833   | -2.0000     | 10.1667 | 1.1667                                | -1.4167 | 0.5833    | -2.0000     | 10.8333 |  |
| 7                                     | -1.0000         | 1.1667  | -0.0833   | 1.1250      | 13.7083 | 1.0000                                | -1.1667 | 0.0833    | 1.1250      | 13.5417 |  |
| 8                                     | 0.7500          | 1.0000  | 0.5833    | 3.8750      | 18.7083 | -0.7500                               | -1.0000 | -0.5833   | 3.8750      | 14.0417 |  |
| 9                                     | -2.6667         | 0.5833  | -3.3333   | -0.5000     | 6.5833  | 2.6667                                | -0.5833 | 3.3333    | -0.5000     | 17.4167 |  |
| Equally weighted average utylity:     |                 | 13.0000 |           |             |         | Equally weighted average utylity:     |         | 12.75000  |             |         |  |
| Not equally weighted average utylity: |                 | 12.9537 |           |             |         | Not equally weighted average utylity: |         | 13.46296  |             |         |  |

Intercept=12.5000.

**Table 5.** Treatment A and B utilities

Utilities for both treatments options of all considered market participants are summarized in Table 5. Equally weighted average utility values (equal to 13.00 and 12.75 respectively for treatment A and B) indicate that aggregated market has other preferences than Patient X, and for pharmaceutical company would be more profitable to introduce into this market treatment A (if all responders provide equal demand for treatment service). However, if Patient X has bigger than others impact on the market (as it was assumed, he creates 30% of demand for treatment services in the market), then treatment B should be introduced as provides greater utility value for considered market (equal to 12.9537 and 13.46296 respectively for treatment A and B).

## CONCLUSION

Patients provide information about their preferences for hypothetical treatment profiles defined by attributes combination. Conjoint analysis decomposes data into components and assigns part-worth utility value for each level of each alternative. The larger range of estimated part-worth utility the more preferred level is. Such characteristics (with the largest value of part-worth utility) are considered to be the most important in predicting patient preferences.

Assuming that treatment concept can be expressed through the design parameters, estimated values of utility function allow to calculate the expected attractiveness of various treatment profiles for each person and can be used to determine which treatment profile would be the most favourable for the given patient with given preferences structure. In light of classical theories of economy, the greater utility from the given treatment concept, the more he/ she is willing to pay for it (if it is within his/her budget).

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