Using Six Sigma Transfer Functions for Analysing Customer's Voice

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Abstract

Purpose: *Marketing surveys based on the one-question approach such as Net Promoter® Score (NPS) have become popular for understanding the customer's experience with respect to various touch-points. The one-question approach avoids the pitfalls of multi-paged questionnaires. However, two issues must be addressed: (i) How can specific information on what drives customer referrals be extracted from a one question survey? and, (ii) Are such surveys suitable to reveal the Voice of Customer (VoC), as required for Lean and Six Sigma?*

The goal of this paper is to explain how such survey results can be leveraged for understanding customer's voice, using Six Sigma concepts. The approach is extensible for covering analysing customer's voice in helpdesk tickets, and from social media, as well.

Approach: *Combined with relevant information about customers from loyalty programs, Customer Relationship Management (CRM) systems, and from social networks, the corresponding customer can be categorized into segments.*

By means of Six Sigma Transfer Functions – a concept used in Design for Six Sigma (Hu and Antony, 2007) – root causes for the received answers can be identified by using Verbatim Analysis, a technique of Quality Function Deployment (QFD), to extract the VoC. Following (Denney, 2005), the root causes that drive the customer's responses are termed Business Drivers. Eigenvector Theory (Kressner, 2005) is used for analysing the response.

Findings: *One-question survey results can effectively be leveraged for understanding customer's voice, by interpretation of the customer's verbatim as Six Sigma transfer functions. This paper explains detection, selection, and validation of business drivers for customer surveys regarding products and services, uncovering perceived importance and satisfaction with their implementation in the software product.*

Research Implications: *While transfer functions in mathematics and signal theory are well understood, its application to Six Sigma requires identifying the right controls from a wide range of possibilities. More than one solution might exist, and it is unknown how to qualify the optimum solution.*

Originality: *Transfer functions link Lean Six Sigma to VoC gathered by marketing and customer communication, replacing lengthy and costly survey questionnaires, thanks to eigenvalues that validate the analysis. This hasn't been published in a journal so far.*

Keywords: *Product Management, Product Innovation, Voice of the Customer, Customer Surveys, Net Promoter® Score, Six Sigma, Transfer Functions, Quality Function Deployment, Business Drivers for Product Improvement, Business Drivers for Software Development.*

Paper type: *Research Paper*

1 Introduction

1.1 Voice of the Customer – by Surveys?

The last few years have seen an abundance of surveys and questionnaires; all intended to orientate an organization towards customer's needs. You cannot stay in a hotel overnight without getting a questionnaire, even your telecom provider or commuter railway asks you whether you found helpful and professional people in their stores or services.

Because interactive surveys via the web have become so cheap, they are used to collect all kind of information from customers or prospects. However, are surveys really appropriate for collecting customer's voice?

Customers are aware of the fact that collectors of information usually know whom they ask, thanks to their CRM system and new sparkling information sources such as social media. So, can they answer honestly, especially if they depend from that service?

Even worse, some surveys (especially in hotels) ask for behaviour characteristics, naturally without taking circumstances into account. Salary and bonuses might depend from such answers. So, what will people answer when they realize that their answer affects the salary payment of their business contact?

Sometime, surveys are created that contains dozens of questions; sometimes, silly questions are asked such as "How skilled were our consultants?" if I hire them exactly for the skills I personally don't have? How should I rate them?

All this is neither lean, nor able to collect Voice of the Customer (VoC). Questionnaire-based surveys reflect the suppliers' view on products and services only, and the responses at best express the customer's consent. That's not VoC!

1.2 The Gemba Way for Getting Feedback

Lean Six Sigma better looks at Gemba ways to get feedback. *Gemba*, (現場 *genba*), is a Japanese term meaning "*the real place*". Gemba refers to the place where value is created: the factory floor, the sales point or where the service provider interacts directly with the customer (*Imai 1997*).

Glenn Mazur introduced this term into Quality Function Deployment (QFD) to denote the customer's place of business or lifestyle *(Mazur, 2009)*. The idea is that to be customer-driven, one must go to the customer's Gemba to understand his use of product or service, using all one's senses to gather and process data.

However, Gemba visits for services provided are not always possible and not always able to properly assess the customer’s experience. For software, usability tests have been widely accepted as a kind of Gemba visits, although tests usually are conducted in lab environments and targeted to improve human interaction design.

On the other hand, bright opportunities for Gemba visits are often ignored: helpdesk tickets and feedback from support interventions. Helpdesk tickets describe an unintended use of some product or service, and thus is a treasure of information for the supplier to understand future business growth opportunities. Nevertheless, it’s ignored because analysing support data is difficult and seems unattractive. Market researchers and quality managers rely on multi-paged, and (from a respondent point of view) time-consuming questionnaires to evaluate customer experience after support interventions, reflecting the supplier view only.

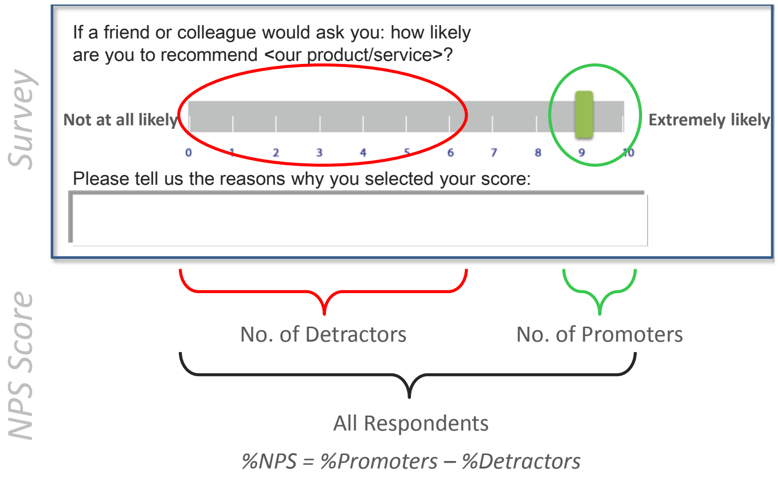


Figure 1: NPS Ultimate Question Score Overview

When Fred Reichheld introduced the *Ultimate Question* approach for surveys *(Reichheld, 2007)*, it was a big step away from the supplier view. By asking one question on how likely the customer is to recommend the supplier towards friends and relatives (not business partners) by means of a scoring scale from 0 (= not at all likely) to 10 (= extremely likely) he brought the customer view, his or her emotions and feelings, into surveys. This is the Gemba approach. Additionally, the customer is invited to comment in his own words why he selected that score.

These comments are the source treasure for analysing VoC. The Net Promoter Score (NPS) itself is not a linear measurement – the respondents scoring with 9 and 10 are called promoters, those scoring between 0 to 6 detractors, and the 7 and 8 passive; the NPS is calculated as the difference between promoter percentage and detractor percentage of the total sample. That metric has been much disputed *(Schneider et. al., 2009)*. Nevertheless, Reichheld claims NPS is predicative for future business growth, and since the NPS approach is not limited to measuring and statistical analysis but to acting upon the feedback received by the customer, he is most probably right *(Owen, 2009)*. The predicative effect is not due to some statistical reason but for the closed-loop work that is also part of the NPS approach. Companies use the NPS to eliminate detractors, convert passives into promoters, and keep promoters by product and process improvement, and this in turn is instrumental to business growth.

However, in order to be able to act upon an NPS survey, we don't need statistical analysis but a verbatim analysis that allows us to understand what the experience of customer in reality is – even if there are thousands of them!

The aim of this paper is to explain that such analysis is possible with little effort, using standard Six Sigma techniques know from Design for Six Sigma (DfSS). For DfSS, see e.g., *(Creveling et. al., 2003)*. How it works is demonstrated for NPS surveys. On the other hand, it is not the aim of this paper to discuss statistical or metronomic significance of NPS.

2 Transfer Functions

2.1 Transfer Functions for understanding Cause-Effect

If root causes in Gemba visits are hidden behind the observed effects, e.g., the VoC behind a support call or complaint, then the method of choice to uncover such causes are transfer functions. Transfer functions map *Controls* onto *Responses*, for instance design decision into product features in DfSS, or Voice of the Engineer onto VoC in QFD. The response is known – observable, measurable – whilst the choice of controls is uncertain, and the optimum control profile sought for designing a product or service right.

A *Transfer Function* f describes the mapping of the input parameters $x_1, \dots, x_n$ to the output y of a process, mathematically expressed as $y = f(x_1, \dots, x_n)$. In DfSS terminology, $x_1, \dots, x_n$ are called *process controls*, denoted by the n-dimensional real-valued column vector $\boldsymbol{x} = (x_1, \dots, x_n)^\intercal$, and the output y is termed the process response. A process with multiple process response is characterised by the m-dimensional real-valued column vector $= (y_1, \dots, y_m)^\intercal$. The vector $\boldsymbol{x}$ is called the *solution profile* and the vector $\boldsymbol{y}$ the *response profile*. Assume all profiles be normalized to vector length one.

A typical example of a single process response transfer function is the duration y for a set of tasks:

$$y = \sum_j x_j + \max(durations\ of\ tasks\ in\ parallel) \tag{1}$$

where the duration of each task j is denoted by x_j , $1 \leq j \leq n$. An example of a multiple process response transfer function is the overall cost $\boldsymbol{y}$ of removing software defects injected in a phase i of a software development process:

$$y_i = \sum_{j=1}^{n} a_{ij}\, x_j, 1 \le i \le m \qquad (2)$$

with a_{ij} represents the number of defects injected in phase i and detected in phase j, and x_j the corresponding cost (2) is a system of linear equations and can be rewritten in matrix-vector notation $\boldsymbol{y} = \boldsymbol{Ax}$, see *(Fehlmann and Kranich, 2011)*. Applications of multiple response linear transfer functions are of special interest in, for instance, Axiomatic Design and QFD, see e.g., *(Yang and El-Haik, 2009)*.

2.2 *Validating Transfer Functions*

A transfer function f may be simple, polynomial, complex function or a composition of other (transfer) functions and its form can be determined by means of statistical techniques such as *Multiple Linear Regression Analysis*, *Design of Experiments* or the *Response Surface Methodology* when experimental data are available, see, e.g., *(Hu and Antony, 2007)*.

However, in DfSS, QFD, and in all sorts of quality management, linear mappings in form of multiple response transfer functions play an outstanding role. For a brief linear algebra background on linear mappings and their relationships to matrices, see *(Fehlmann and Kranich, 2011)*, *(Lang, 1973)*, and *(Roman, 2007)* for further details.

Let $f: \mathbb{R}^n \to \mathbb{R}^m$ be a linear multiple response transfer function. This function can be represented by an $m \times n$ matrix $\boldsymbol{A} \in \mathbb{R}^{m \times n}$, and let $\boldsymbol{A} = \left(a_{ij}\right)$ be its components, $1 \le i \le m, 1 \le j \le n$. To each linear mapping, its dual linear mapping $f^\top: \mathbb{R}^m \to \mathbb{R}^n$ is the transpose of the matrix $\boldsymbol{A}$, i.e., $\boldsymbol{A}^\top = \left(a_{ji}\right)$. The matrix product $\boldsymbol{AA}^\top$ is symmetric and – in most cases – positive definite, i.e., $\boldsymbol{y}^\top \boldsymbol{AA}^\top \boldsymbol{y} > 0$, for all $\boldsymbol{y} \in \mathbb{R}^m \setminus 0$.

Symmetric positive definite matrices have real – non imaginary – *eigenvalues* and therefore its associated transfer function has a principal *eigenvector*. The eigenvector $\boldsymbol{y}$ is characterized by the equation $\lambda \boldsymbol{y} = \boldsymbol{AA}^\top \boldsymbol{y}$, where the eigen-value $\lambda = 1$ because of the assumption all profiles have length zero. If $\boldsymbol{y}$ is a – measured or otherwise known – response profile, then $\boldsymbol{x} = f^\top(\boldsymbol{y})$ is a candidate solution profile.

Now calculate the Euclidian difference between the known response profile $\boldsymbol{y}$ and the candidate controls profile $\boldsymbol{y}' = f(\boldsymbol{x}) = f(f^\top(\boldsymbol{y}))$:

$$\|\boldsymbol{y} - \boldsymbol{y}'\| = \sqrt{\sum_{j=1}^{m} \left(y_j - y'_j\right)^2} \qquad (3)$$

(3) is called the *Convergence Gap*. If the convergence gap is zero, the vector $\boldsymbol{y}$ is an eigenvector of $\boldsymbol{AA}^\top$ to the eigenvalue 1, since all profiles are assumed to be normalized to length one. If the convergence gap is sufficiently close to zero, i.e., within predefined limits, the controls $\boldsymbol{x} = f^\top(\boldsymbol{y})$ are still good enough. For some applications like QFD and AHP, the convergence gap is

used for validating the expert analysis of the transfer function (in AHP: the pairwise decision matrix). The eigenvector theory eliminates the measurement errors made in the expert analysis using redundant information in the decision matrix. A similar statement also holds for QFD. For a theoretical background regarding QFD matrices, see *(Fehlmann, 2005)*.

If the vector $\boldsymbol{y}$ is out of the limits for an eigenvector, it doesn't define acceptable controls. The inequality $\boldsymbol{y}' \neq f(f^{\top}(\boldsymbol{y}))$ means that the transfer function applied to the controls $\boldsymbol{x} = f^{\top}(\boldsymbol{y})$ yield some significantly different response than the response profile vector $\boldsymbol{y}$ that was observed, or required. Therefore, it is no solution to the problem of finding suitable controls for getting the response within allowable limits.

2.3 Finding the Right Controls

It is obvious how eigenvectors can be used to find optimum solutions for any problem of the form $\boldsymbol{y} = f(\boldsymbol{x})$ where $\boldsymbol{x}$ is unknown. As already mentioned, the convergence gap plays an invaluable role in QFD and DfSS for validating controls. In QFD for instance, the transfer function is found by collecting expert opinion for each of the matrix cells. In DfSS, the cell values are measured by *Design of Experiments* (DOE), or other Six Sigma tools.

A natural question arises: how many controls are needed to guarantee the expected response with minimal cost? Most often more dimensions are needed for the controls than for the observed response profile. Therefore $m \leq n$ holds. Otherwise, some of the responses would be interdependent and thus redundant; the dimensions of control and response profiles behave like degrees of freedom in mathematical statistics.

In practice, control profiles must be mapped to some real domain controls that allow guaranteeing the observed response accurately enough. How this works will now be explained for VoC analysis.

3 Voice of the Customer Analysis

3.1 Building Transfer Functions from VoC

Generally, VoC is expressed with words and statements. The most popular and widely used analysis method for such VoC is *Verbatim Analysis*. The basic technique of verbatim analysis is to apply Six Sigma's affinity diagram developing procedure to VoC.

This technique is hard to automate because of the variety of natural language and the difficulty of recognizing semantics. Most customer verbatims require a context for understanding. Nevertheless, for surveys or support tickets that amount to a few hundred samples, manual analysis is feasible. Since there is not much of higher value than a customer verbatim, it pays off. It's no waste.

3.2 Business Drivers

Transfer functions origin from analysis of signals and systems such as Fourier transforms *(Girod et.al., 2001)*. The principle of customer verbatim analysis is similar to signal theory. It is called *frequency analysis*; instead of counting wave functions, you count how often certain words or notions are referenced. The customer verbatim is categorized into references to some *Business Drivers (Denney, 2005)*. It is advisable to take as few business drivers as possibly needed for explaining the observed behaviour in the response. Most domain experts know business drivers quite well, and the customers itself supply keywords that allow detecting new business drivers unheard so far. Analysing social media and community discussions might help as well for selecting a suitable set of business drivers.

If frequency of references is collected and matched to the various customer segments, a multi-response transfer function is defined that maps frequency of verbatims to segment responses. The frequency yields a profile for the $\boldsymbol{x}$-axis of the matrix. The response profile we get from the NPS score by segments.

3.3 Measurement Errors

In reality, the observed response profile $\boldsymbol{y}$ as well as the transfer function $\boldsymbol{A}$ (the result of verbatim analysis) is subject to measurement errors. Respondents may not understand the NPS scale and skew their score. Availability of context information and verbal skills impact the verbatim analysis; language sometimes is fuzzy and people don't express them correctly. Written statements often contain syntax flaws and the semantics are not clear. Humans knowing the context may understand better, but for an analysis tool it might become rather complicated.

However, the eigenvector theory yields a test for such frequency analysis. Assume $\boldsymbol{A}$ the matrix found by verbatim analysis; if the analysis is correct, $\boldsymbol{AA}^{\intercal}$ must have an eigenvector $\boldsymbol{\tau}$ with $\boldsymbol{\tau} = \boldsymbol{AA}^{\intercal}\boldsymbol{\tau}$. Let $\boldsymbol{y}$ be the survey response profile; ideally $\boldsymbol{y} = \boldsymbol{AA}^{\intercal}\boldsymbol{y}$ and therefore, since $\boldsymbol{\tau}$ is a principal eigenvector, it would hold $\boldsymbol{\tau} = \boldsymbol{y}$. Thus the Euclidian difference $||\boldsymbol{\tau} - \boldsymbol{y}||$ is a size metrics for the total *Measurement Error* of both the response measurement $\boldsymbol{y}$ and the transfer function $\boldsymbol{A}$.

3.4 Adjusting the Analysis

Since calculating an eigenvector in practice is very easy, both measurement error and convergence gap might be used to identify mistakes done in the verbatim analysis. However, the measurement error has the advantage that it doesn't depend from the choice of controls; thus it is the primary choice for identifying mistakes in the verbatim analysis.

For verbatim analysis, most often the fuzzy meaning can be interpreted in the several ways, and the preferred way is such that the analysis result matches the overall observed response, i.e., the measurement error decreases.

This principle allows for defining algorithms that do the verbatim analysis automatically. Not unlike multiple linear regressions, searching for minimal measurement error yields an improved transfer function $\boldsymbol{A}$ and therefore an improved $\boldsymbol{\tau}$ as well from the frequency analysis.

With that improved transfer function $\boldsymbol{A}$, the control profile $\boldsymbol{x} = \boldsymbol{A}^{\intercal}\boldsymbol{y}$ can be calculated and compared to its convergence gap.

4 Lessons Learned

4.1 Benefits

NPS surveys can deliver more information than traditional questionnaire-based surveys can by not reflecting the supplier view but by stimulating customer's voice through an emotional channel.

Verbatim analysis is well understood in the Six Sigma community and tools are available to extend it for much larger response samples than only a few hundred. Transfer functions, validated by the eigenvector theory, play a major role in DfSS and thus can easily be adapted to understand VoC when physical Gemba is impossible.

NPS surveys are popular, well-received by customers, transport an important message to the respondent, namely how important it is to recommend his or her preferred supplier, and allow for better Gemba in service areas.

The predictive value of NPS lies in the actions and follow-ups, in personal contacts with respondents, in process improvement where needed, in better meeting business requirements of customers.

4.2 Limitations

If importance and satisfaction differ too much, or if NPS is not applicable because it's negative, the eigenvector validation method doesn't work as nice. However, this is easy to test, and the responses itself are still helpful even if they cannot explain the observed NPS.

Verbatim analysis for large survey samples require a sophisticated tool set for automatic analysis of the responses. However, the eigenvector theory also softens mistakes made in the analysis.

If business drivers are unknown, or not able to explain the observed NPS, the verbatim analysis can still be used to find relevant drivers.

4.3 Managerial Impact

The NPS approach described in this paper offers the ability to extract the essential business drivers reflecting the Gemba VoC. Hence, the NPS approach – when combined with Six Sigma transfer functions and eigenvector theory – helps managers and strategic decision makers of a company to promptly produce products or services the customers really want, even in the case when the free-text answer is fuzzy in some sense. Again, this emphasizes the advantage of using a constructive method against a purely descriptive statistical approach.

4.4 Future Steps

In the past, the authors conducted and analysed a small number of NPS surveys with at most 300 respondents in the *Business-to-Business* (B2B) environment. Since the results proved to be very promising, a first step is to conduct NPS surveys with much larger samples in *Business-to-Consumer* (B2C) settings, probably for a large company. It is of special interest in such an environment how and by means of which tools the verbatim analysis can be performed efficiently.

The subject of the second step is to carry out a comparison of the NPS results and those results obtained by traditional statistical methods for calculating customer's satisfaction.

5 Outlook and Conclusion

Business Drivers is a valuable concept for analysing customer's voice. NPS measures the probability of referrals, resulting from their importance, and from satisfaction with them. Both transfer functions are validated by its eigenvector.

Eigenvector theory is a constructive, not empirical, method for analysing cause-effect relationships. It is useful in many business areas, as presented here when analysing business drivers that cause high NPS in surveys for a software vendor. Eigenvectors also enable software project managers to establish self-control for reaching business goals, such as to deliver the business driver's importance profile found in the survey; see *(Fehlmann, 2011)*. The method is easy to use and requires no more investments than doing an NPS survey right, knowing your customer base, and requires some rather simple vector calculations involving linear algebra.

Transfer functions for verbatim analysis method is well suited to NPS surveys but can be easily adapted to any free-text analysis, including support cases and customer feedback received through social media and chat forums.

6 Appendix: A Sample NPS Survey

The following section exemplifies the NPS approach described in this research paper in a practical context.

6.1 Sample NPS Profile

We assume a travel company collected feedback using an NPS survey for their helpdesk service helping in case of service disruption or cancellations.

Table 1: Sample NPS Profile According Customer Segments

		NPS	Profile
NPS-1	Young Traveller	20%	2.8
NPS-2	Business Traveller	17%	2.3
NPS-3	Holiday Traveller	20%	2.8
NPS-4	Elderly Leisure	14%	2.0

The NPS profile in Table 1 is calculated by normalization.

NPS scores are not continuous satisfaction ratio scales. The eleven selectable scores between 0 and 10 collapse into three groups: promoters, passives, and detractors. Only promoters and detractors are explicitly included in the calculation. When both young and holiday travellers score with 20%, a significant difference in the number of passives still might exist. Only passives moved into promoter or detractor status affect the overall score.

6.2 Sample Verbatim Analysis

We use five business drivers for performing verbatim analysis, see Table 2. The business drivers reflect the customer's viewpoint.

Table 2: Suspected Business Drivers for Verbatim Analysis in the Sample Case

	Topics	***Attributes***
BD-1	Responsiveness	No waiting loops – immediate response
BD-2	Compelling	Can commit for connections and reimbursement
BD-3	Friendliness	Keeps cool under stress – calm down
BD-4	Personal	Knows frequent travellers from login or mobile
BD-5	Competence	Able to solve traveller's problem

Analysing the customer verbatims now allows counting how many times each of the five suspected business drivers has been referenced in one of the responses. It can be explicit or by some predefined keyword that refers to it, e.g. "know me", "preferred", "my preference" for BD-4: "Personal". The reference can be positive or negative. Counting all positive references means assessing how important the topic is for the sample. Positive and negative references are indicative for satisfaction with the respective business driver. The passives must be taken into account for the frequency analysis. Since passives cannot affect the overall NPS, the verbatims for their group must be weakened accordingly for the frequency count. This is called the *Attenuation Factor*.

Obviously, NPS surveys do not measure customer satisfaction but something else: the willingness to let the suppliers business grow by recommending it.

6.3 Sample VoC Analysis

Conducting frequency counts results in two transfer functions: one explains the observed NPS score from the importance (Figure 2), the other takes satisfaction into account and thus might even become negative, see Figure 3.

Not both transfer functions are always capable of explaining the observed score. Usually, importance is better explained than satisfaction if the overall NPS is positive; negative NPS cannot be explained by a positive definite transfer function, and eigenvectors exist only as long as the $\boldsymbol{AA}^\intercal$–matrix remains positive. Thus, with satisfaction below a certain level, this VoC–Analysis might be inappropriate for the purpose.

Figure 2: Sample Importance Transfer Function

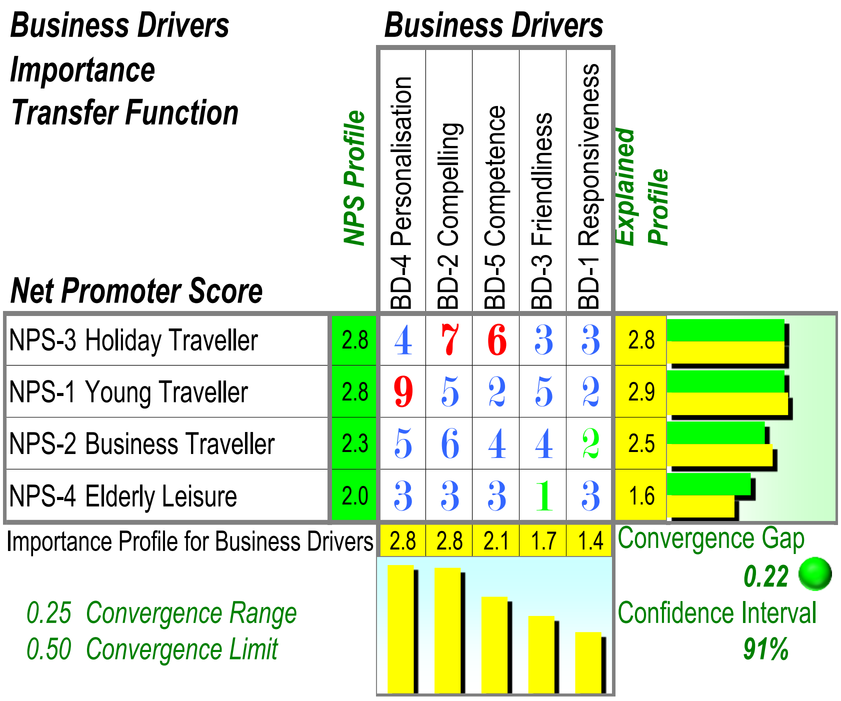
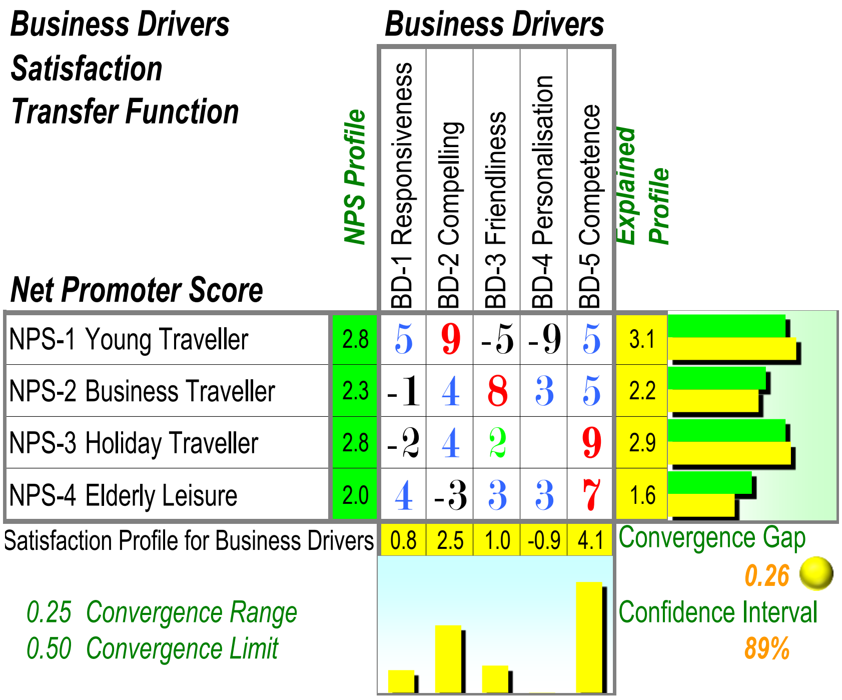


Figure 3: Sample Satisfaction Transfer Function



More details about the frequency counting and evaluation method can be found in *(Fehlmann, 2011:2).*

6.4 *Findings from this Analysis*

In our case, it can be seen that satisfaction with the ability to recognize frequent travellers personally from their web login or mobile number is unsatisfactory but quite important for the sample respondents. This yields clear advice where to invest into service improvement next.

Satisfaction explains the observed NPS less good than importance – it could hint at the willingness of respondents that the sample travel company is able to improve, and better meet the business drivers deemed important.

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