Six Sigma for Analyzing Market Preferences

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Abstract: The New Lanchester Theory links Business Objectives to market share using a transfer function, known from Six Sigma and Quality Function Deployment (QFD). The transfer function can effectively be used for prioritizing new features for software products. However, it is not easy to define this transfer function. This paper presents current practices and new opportunities for software marketing that arise from recent advances in Six Sigma theory.

1 Introduction

1.1 What are Market's Preferences?

This chapter explains why market's preferences – essential for software products – are on a different level than customer's needs in a project QFD. Market's needs are different – the market decides based on preferences rather than on analyzing individual customer's needs, formulating requirements and assessing whether the software product meets these requirements. Many voices shape such preferences – professional journals, trade magazines, experiences made, assumptions and prejudices play their roles. In ICT, market preferences are expressed as a selection of product features – those features that are relevant when evaluation products and doing buying decisions. Sometimes, this market selection is quite a surprise for the supplier of the product – for instance, when adopting mobile telephones, the market decided for a precedence for the Short Message Service (SMS text messages, originally designed for internal use only when servicing network hubs), it was not expected for inventors and providers of that service.

The *Deming Value Chain* consists of a series of transfers from one value chain topic level into another. It depends on the domain; for instance, with software it looks as shown in Figure 1. Advice how to set up a Deming Value Chain for various deployments is available in the Quality Function Deployment Best Practices [07]. W. Edwards Deming published organizational production chain deployment schemes in the early 1930'ies already [03]. Prof. Akao used similar schemes for "QFD in the Broad Sense" [01]. This is the reason for calling such deployments Deming Value Chain.

However, when no direct customer is involved into development, Voice of the Customer is not as readily available as for customer software projects, project sponsors cannot formulate requirements by analyzing customer's needs; thus product management has to guess somehow what the potential customers want. Nevertheless, it is possible to predict market precedence using the power of Six Sigma and of Deming Value Chains.

1.2 Deming Value Chains

Deming Value Chains link Deming Value Creation Processes, value-added production steps that transform resources into business value.

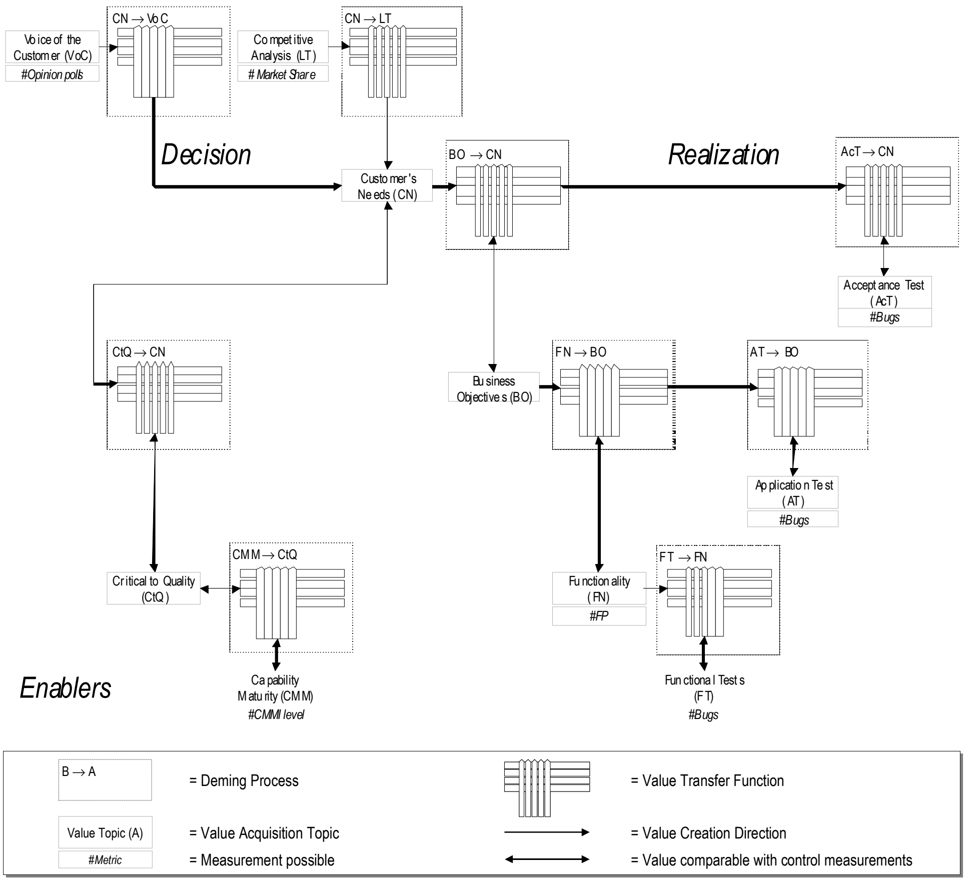

Figure 1: Deming chain for software project deployment

We write **B** → **A** when **B** is a set of resources that result in business values **A**. For instance, Customer's Needs (**CN**) result in Voice of the Customer (**VoC**) that reflects those needs **CN** → **VoC**. Customer's Needs (**CN**) also cause buying decisions (**CN** → **LT**; LT stands for "Lanchester Theory", see below) reflecting the same needs. In turn, Use Cases (**UC**) must meet Customer's Needs (**UC** → **CN**); i.e. they fulfill those needs what we also understand as sort of production process. In this sense, we adopt and re-use Deming's value chains for software and service purposes.

Obviously, knowing about **VoC** and **LT**, the software supplier should understand Customer's Needs (**CN**), and, if successfully understanding **CN**, he should be able to formulate Use Cases (**UC**) – or User Stories, whatever approach he might take – and finally propose suitable functionality (**FN**). Knowing the results aimed to in the Deming Value Chain does not automatically define which resources provide them.

There is also an upward branch: Test Stories (**TS**), Application Tests (**AT**), and Acceptance Tests (**CT**) support the respective topic according their level; and there is a second downward branch in the value chain that deals with non-functional requirements such as the Critical-to-Quality (**CtQ**) characteristics, and process maturity (**CMM**) needed to meet such quality characteristics.

1.3 Deming Value Chain for Software Products

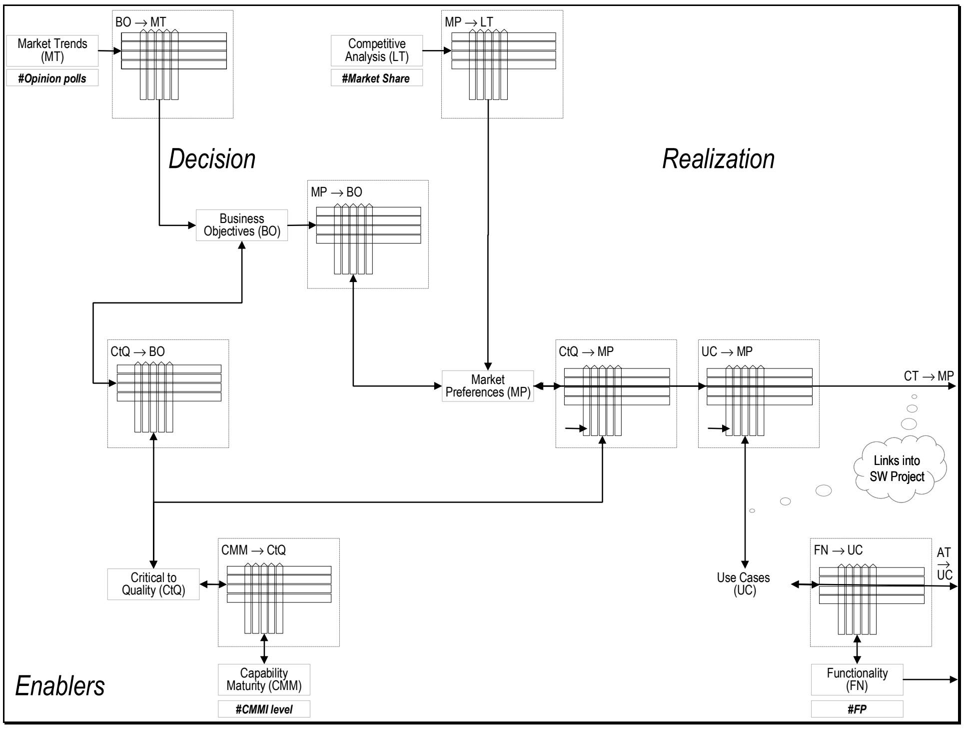

Figure 2: Deming Value Chain for software product deployment

When setting up the Deming value chain for software products, there is a significant difference (Figure 2). Not Customer's Needs (**CN**) are pivotal but *Business Objectives*

(**BO**). Market preferences develop around business objectives; the selection and valuation of business objectives changes when market preferences evolve.

The Deming Value Chain starts with *Market Trends* (**MT**). Market trends are harder to assess, they are the result of decisions made by market players about their *Business Objectives* (**BO**) which in turn depend from *Market Preferences* (**MP**) rather than from Software Engineering artifacts directly. Both the functionality offered for Use Cases in the software product, as Critical-to-Quality (**CtQ**) characteristics impact market preferences. This makes the Deming Value Chain for software products deployment significantly more complicated than for software projects.

A software project is needed to create a software product, but the software engineering artifacts such as use cases or test cases link not to requirements or customer's needs, but to market preferences. Moreover, market preferences depend both from critical-to-quality characteristics and from the use case functionality provided by the product. Thus both quality characteristics and functionality are more difficult to align to software product development than in a software project. Moreover, no formal acceptance testing is possible; the market decided probably based on pilot experiences but not on tests.

1.4 Control by Measurements

Six Sigma offers metrics and tools needed to provide *Decision Metrics* to this Deming Value Chain, by linking the controls to observable facts. A decision metric is an evaluation function **A** $\rightarrow$ **A** that yields stable results, where **A** is some business value topic. This means, repeating the decision method always yields the same results.

Market preferences are not directly measurable; but surveys, market research provide observable measurements, and market share is measurable. Using Six Sigma *Transfer Functions*, we can measure market preferences indirectly; however, we need to know how reliable such indirect measurements are. A Transfer Function is an evaluation of a Deming process **B** $\rightarrow$ **A.**

Competitors excel at different levels with respect to market preferences; this is called a *Competitive Profile*. The difference between market preferences and the competitive profile can be measured using the *Convergence Gap*, which is the length vector difference between the market preference vector and the competitive profile vector, measured in the linear vector space of market preferences.

2 What are Transfer Functions?

In general, observations such as market share, buying decisions, Voice of the Customer, or customer complaints can be measured. However, if those observed and measured facts are not as favorable as they probably should be, if variations are too high, Six Sigma aims at knowing their causes, and becoming able to influence the causes with suitable controls such that future observations are more satisfactory. The dependency of observed facts from controls is called *Transfer Function*.

In mathematical terms, if we have more than one observation and more than one control for the solution, we use the term "*Vector*" for such multidimensional observation profiles and solution profiles. If **y** denominates the vector profile of the observed facts, and **T** is the transfer function that links the control profile vector **x** to the target, then **T**(**x**) = **y** indicates that the controls are capable to always hit the target. Then, hit rate is within the six sigma tolerance range.

T transfers solution vectors **x** into results **T**(**x**), called '*response*' [02]. These responses can be measured and compared with the initial observations **y**. If the variations between observation **y** and the responses **T**(**x**) for all solution vectors **x** are all within the six sigma tolerance range, the responses become *predictable*.

Transfer Functions are used for prediction. In Six Sigma, prediction models are build for measurable business observations (the '**y**'s, e.g., defect density, project costing) with the aim to control the solution-impacting factors '**x**' so well that the response (i.e., the process results **T**(**x**)) are forced into the allowable tolerance range around the **y**'s.

The entities **x** and **y** are vector profiles since neither observation nor influencing factors come alone, or without constraints. The vector spaces that we consider represent business requirements and solution approaches, respectively. These vector spaces accommodate statistical events, such as requirement definition, or solution design.

Multidimensional vector spaces are much more common that usually felt; for instance, a normal distribution of events is a vector in a multidimensional vector space, its dimension being the degree of freedom, i.e., the number of mutually independent events. Such normal distributions can be quite large and the dimension is not limited.

2.1 Problem Statement

A typical problem statement is: the observation profile **y** is known; various controls exist but it is unknown which controls are effective and which are not. The control profile **x** is unknown, even if there are enough candidate controls that seem applicable.

The usual solution approach is to investigate the characteristics of the transfer function **T** that explains how **x** impacts **y**. In mathematical terms: the problem statement is **T**(**x**) = **y**, where **x** is unknown.

The number of independent dimensions needed for the control space is equal or higher than for the observation space. Otherwise dimensions wouldn't be independent.

2.2 Matrix Representation of Transfer Functions

If the transfer function **T** is *linear*, **T** can be expressed as a matrix. For this, select a set of *base vectors* both in the space of controls $\underline{\mathbf{x}}$, say $\underline{\mathbf{a}}_1, \ldots, \underline{\mathbf{a}}_n$; as in the space of observations $\underline{\mathbf{y}}$, say $\underline{\mathbf{b}}_1, \ldots \underline{\mathbf{b}}_m$. Every vector $\underline{\mathbf{x}}$ can be written as $\underline{\mathbf{x}} = \xi_1\underline{\mathbf{a}}_1 + \ldots + \xi_n\underline{\mathbf{a}}_n$, the ξ_i being scalar values, called *components* of $\underline{\mathbf{x}}$. Assuming the base vectors as fixed, the vector $\underline{\mathbf{x}}$ is written simply as $\underline{\mathbf{x}} = < \xi_1, \ldots \xi_n >$. Then a Transfer function **T** can be written as a matrix because every base vector $\underline{\mathbf{a}}_i$ yields a component representation in the space of observations $\underline{\mathbf{y}}$:

$$\mathbf{T}(\underline{\mathbf{a}}_i) = < \tau_{i,1}, \ldots \tau_{i,m} > \tag{1}$$

for all i=1…*n*. The components $\tau_{i,j}$ represent **T** as component matrix (i=1…*n*, j=1…*m*):

$$\mathbf{T} = \begin{bmatrix} \tau_{1,1} & \tau_{1,2} & \cdots & \tau_{1,m} \\ \tau_{2.1} & \tau_{2,2} & \cdots & \tau_{2,m} \\ \cdots & \cdots & \cdots & \cdots \\ \tau_{n,1} & \tau_{n,2} & \cdots & \tau_{n,m} \end{bmatrix} \tag{2}$$

Let $\underline{\mathbf{x}} = < \xi_1, \ldots \xi_n >$ and $\underline{\mathbf{y}} = < \psi_1, \ldots \psi_m >$ for some fixed base vector sets. Then the equation $\underline{\mathbf{y}} = \mathbf{T}(\underline{\mathbf{x}})$ can be written in component form (*matrix multiplication*):

$$\underline{\mathbf{y}} = \left\langle \psi_1 = \sum_{i=1\ldots n} \tau_{i,1}\xi_i, \quad \psi_2 = \sum_{i=1\ldots n} \tau_{i,2}\xi_i, \quad \ldots, \quad \psi_m = \sum_{i=1\ldots n} \tau_{i,m}\xi_i \right\rangle \tag{3}$$

Every transfer function has a transpose, denoted as $\mathbf{T}^{\mathbf{T}}$, whose matrix elements are constructed by switching rows with columns. Assume the matrix representation of **T** has *n* rows and *m* columns; $\mathbf{T}^{\mathbf{T}}$ has *m* rows and *n* columns. *n* is called the *dimension* of the control space, and *m* is the dimension of the observation space.

$$\mathbf{T}^{\mathbf{T}} = \begin{bmatrix} \tau_{1,1} & \tau_{2,1} & \cdots & \tau_{n,1} \\ \tau_{1,2} & \tau_{2,2} & \cdots & \tau_{n,2} \\ \cdots & \cdots & \cdots & \cdots \\ \tau_{1,m} & \tau_{2,m} & \cdots & \tau_{n,m} \end{bmatrix} \tag{4}$$

In more business-related words, *n* is the number of controls in $\underline{\mathbf{x}}$ needed to observe the response $\underline{\mathbf{y}}$ that in turn has profile length *m*. $\mathbf{T}^{\mathbf{T}}$ looks similar to a Transfer function but works on the observation profile $\underline{\mathbf{y}}$: $\mathbf{T}^{\mathbf{T}}(\underline{\mathbf{y}})$ yields a possible solution profile $\underline{\mathbf{x'}} = \mathbf{T}^{\mathbf{T}}(\underline{\mathbf{y}})$ that is in the same space as the unknown "ideal" solution profile $\underline{\mathbf{x}}$, fulfilling $\mathbf{T}(\underline{\mathbf{x}}) = \underline{\mathbf{y}}$; but in contrary to the unknown $\underline{\mathbf{x}}$, it can be computed easily once **T** is known. Applying

T to **x’** yields **T**(**x’**) = **y’**; this is the response that effectively can be achieved with the solution profile **x’**. This response is called *Prediction*. A prediction can be compared with an observation.

The question is: how far away from **y** is **y’**? The mathematical theory of linear vector spaces gives a straightforward answer: the $\mathscr{L}_2$ vector space norm defines length of a vector, and the distance between two vectors is the length of the vector difference. Vectors can be subtracted by computing the differences between their respective components[1]. In the Euclidian space where we live, $\mathscr{L}_2$ is what we usually call distance between two points in space; a measurable entity, not depending from the measurement direction. In a Six Sigma statistical vector space, the $\mathscr{L}_2$ norm measures distributions.

Let **y** = $< \psi_1, \ldots \psi_m >$ be the observation and **y’** = **T**(**x’**) = **T**($\mathbf{T}^{\mathbf{T}}$(**y**)) = $< \psi'_1, \ldots \psi'_m >$ be the prediction. The distance is written with two double-bars ||…||. For normalization reasons[2], we divide the result by square root of the dimension *n*:

$$\|\mathbf{y} - \mathbf{y'}\| = \sqrt{\frac{\sum_{i=1..n}(\psi_i - \psi'_i)^2}{n}} \tag{5}$$

The difference is called *Convergence Gap*. For instance, take a normal distribution of events $< \xi_1, \ldots \xi_n >$. As seen before, this is a vector in a multidimensional vector space, its dimension being the number of mutually independent events.

Now compare the events vector $< \xi_1, \ldots \xi_n >$ with the vector whose components consist all of the same arithmetic mean $\overline{\xi}$.

$$\overline{\xi} = \frac{\sum_{i=1..n}\xi_i}{n} \tag{6}$$

Take the $\mathscr{L}_2$ vector norm distance between that distribution vector and the arithmetic mean point in the observed vector space of events:

$$\sigma = \sqrt{\frac{\sum_{i=1..n}(\xi_i - \overline{\xi})^2}{n}} \tag{7}$$

Formula (7) is the definition of the standard deviation sigma indicating the variance of the normal distribution[3]. Thus, the standard deviation is the vector difference between

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[1] It is left to the reader to assess the strange characteristics of $\mathscr{L}_1$, the maximum norm for vectors – the length of the vector is determined by its maximum components – or $\mathscr{L}_3$, replacing squares by cubicles. Comparison of two vectors is useless in $\mathscr{L}_1$, or $\mathscr{L}_3$; but in $\mathscr{L}_2$, normalized vectors can be compared, see [04].

[2] The reason for the division through the square root is discussed in [04].

$\langle \xi_1, \ldots, \xi_n \rangle$ and $\langle \overline{\xi}, \ldots, \overline{\xi} \rangle$, since normal distributions are a very simple example of a Transfer Function trying to hit the arithmetic mean point.

Real life transfer functions are more complicated than normal distributions; when studying market preferences, normal distributions are very rare. Actual Convergence Gaps are seldom exactly zero, but it is sufficient if they are small enough.

2.3 Combining Transfer Functions

Given two transfer functions $\mathbf{T}_1$ and $\mathbf{T}_2$ where the goal or observation space of $\mathbf{T}_2$ corresponds to the solution space of $\mathbf{T}_1$, it is common practice to combine a composite transfer function by first applying $\mathbf{T}_1$ and then $\mathbf{T}_2$. The definition for all vectors $\underline{\mathbf{x}}$ is

$$[\mathbf{T}_1 \bullet \mathbf{T}_2](\underline{\mathbf{x}}) = \mathbf{T}_1\,(\mathbf{T}_2(\underline{\mathbf{x}}))$$

The combination of two transfer functions corresponds to the sequential chaining in the Deming Value Chain; for instance, when $\mathbf{T}_{\mathbf{MP \rightarrow LT}}$ denotes the transfer function between market preferences and market share according Lanchester Theory, and $\mathbf{T}_{\mathbf{CtQ \rightarrow MP}}$ the transfer function between Critical-to-Quality characteristics and market preferences, then $\mathbf{T}_{\mathbf{MP \rightarrow LT}} \bullet \mathbf{T}_{\mathbf{CtQ \rightarrow MP}}$ is the combined transfer function that describes the influence of quality characteristics on market share. For business and design decisions, this is very valuable information.

2.4 Consistency of Transfer Functions

However, combinations are not only useful when looking at Deming Value Chains. Using the transpose $\mathbf{T}^\mathbf{T}$, we have already seen that the combination $\mathbf{T} \bullet \mathbf{T}^\mathbf{T}$ has interesting characteristics.

If $[\mathbf{T} \bullet \mathbf{T}^\mathbf{T}](\underline{\mathbf{y}}) \cong \underline{\mathbf{y}}$, $\mathbf{T}$ is a *Consistent Explanation* for $\underline{\mathbf{y}}$ since we can repeatedly apply $\mathbf{T} \bullet \mathbf{T}^\mathbf{T}$ to $\underline{\mathbf{y}}$ and always get the same result: $\underline{\mathbf{y}} \cong [\mathbf{T} \bullet \mathbf{T}^\mathbf{T}](\underline{\mathbf{y}}) \cong [\mathbf{T} \bullet \mathbf{T}^\mathbf{T}]([\mathbf{T} \bullet \mathbf{T}^\mathbf{T}](\underline{\mathbf{y}}))$ and so on. This technique has been used extensively with Analytic Hierarchical Process (AHP). [10]; it explains why AHP is a decision metric. Contrary to other decision methods sometimes used in business[4], AHP can be applied repeatedly and still delivers consistent results. This makes AHP valuable and successful when doing decisions based on incomplete knowledge.

If $\mathbf{T}$ is a consistent explanation for $\underline{\mathbf{y}}$, $\mathbf{T}^\mathbf{T}(\underline{\mathbf{y}})$ is an approximate solution for the problem $\mathbf{T}(\underline{\mathbf{x}}) \cong \underline{\mathbf{y}}$. The main problem with transfer functions is to solve the problem $\mathbf{T}(\underline{\mathbf{x}}) = \underline{\mathbf{y}}$, that means to find the elements of the profile vector $\underline{\mathbf{x}}$ that describes the relevant market preferences. Such preferences govern buying decisions and are thus decisive for product success on the market.

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[3] Actually, σ is the *Maximum Likelihood Estimate* for the standard deviation in a normal distribution.

[4] For instance, the popular "Pair-wise Comparison" method is well-known for suggesting wrong decisions.

With the Convergence Gap, there is a simple method to check whether **T** provides a consistent explanation for **y**. This we can use to investigate market preferences based on incomplete data and soft factors.

2.5 A Simple Example

The following simple example may illustrate the problem. It originates from a QFD Workshop analyzing the market share trends for a *customer phone number inquiry help desk* in a former monopolistic telecom company that has moved into a new competitive environment. The market share was measurable; other emerging phone companies with own help desk operations published numbers. However, customer segmentation was unknown – the assumption was people with limited access to Internet.

We build a transfer function between customer preferences and market share that maps the competitive profile of each competitor onto market share. The “Predicted Profile” to the right is the result of multiplying the “Competitive Profile for Market Preference” with the matrix, and normalizing it. It compares with the “Observed Profile”.

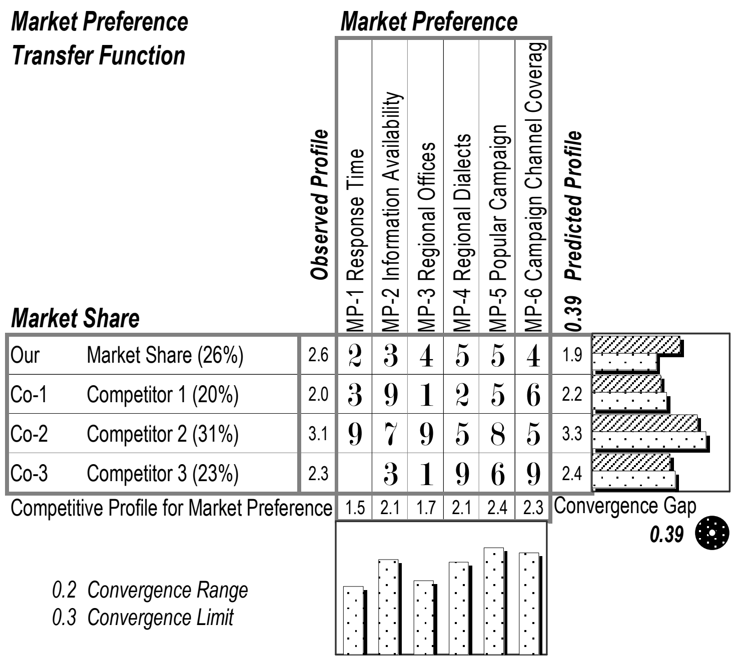

Figure 3: Transfer function not explaining observed market share

In theory, the expectation is that competitors share the market according their specific competitive advantages. In reality, this is not necessarily true.

The matrix cells result from a Quality Function Deployment workshop; they reflect in each column the relative performance of competitors against one market preference topic. The competitive ranking of the controls MP-1: “Response Time” was measurable; Data for MP-2: “Information Availability” was gained with some test calls; MP-3: “Regional Offices” and MP-4: “Regional Dialects” have been measured as well, while MP-5: “Popular Campaign” and MP-6: “Campaign Channel Coverage” were assessed by workshop team agreement.

Nine is highest, zero or empty is least. Equal settings are admissible.

Since the evaluations originate from a real business case, the actual competitors are not shown in Figure 3 until Figure 6. Market shares are shown as a normalized profile vector; for historical reasons [04] the vector components range between 0 and 5.

Clearly there is something missing in Figure 3 that explains why the observed “Our Market Share (26%)” in the observation profile is higher than the predicted market share. The missing market preference factor seemed not related to any technical or organizational feature; rather to the fact that our product was well known and trusted for its long existence. We did call that the *Trust Factor*.

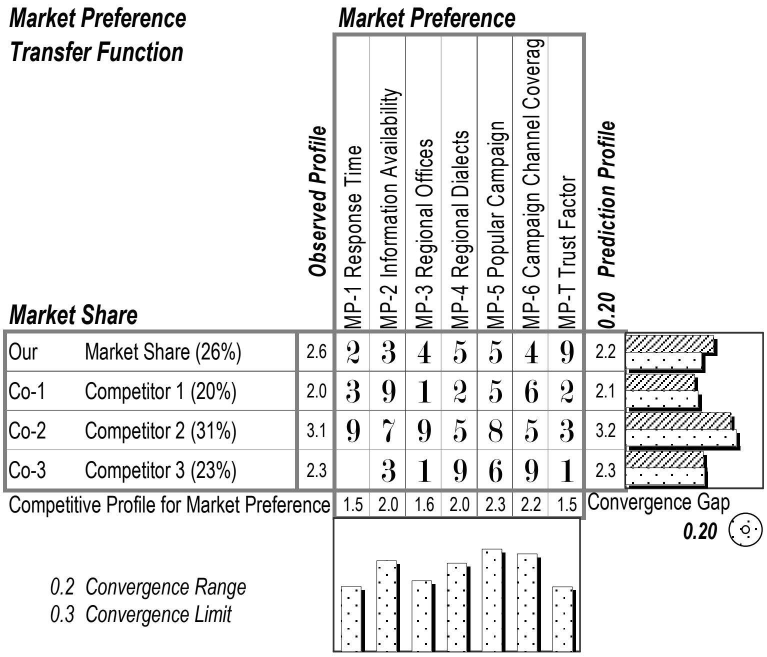

Figure 4: Transfer function better explaining observed market share

Note that the Trust Factor as a market preference has been detected by analyzing the example above only. The competitive ranking was made with a short random survey among people, partly within and partly outside of the organization.

Since the Convergence Gap is now better, there is reason to believe that this extended set of customer preferences – the market preference profile vector **x** with the trust factor added – really reflects market reality. The transfer function makes it possible to quantify the relative importance of the trust factor versus other factors.

However, the Convergence Gap of *0.20* is at the limit of the stated *Convergence Range* – the range of trust defined in view of the data quality – and thus unsatisfactory.

Since market preferences are not customer requirements, it might be interesting to see what happens if we remove some of the Market Preferences. Since these preferences are assumptions not stated requirements, it is tempting to experiment with removing some of the supposed market preferences in order to see what happens.

As candidates for removal, two groups with three topics were identified

1. MP-2: "Information Availability" is not relevant for market preference, because the users of the help desk won't notice if information isn't available.

2. Although the two regional product features (MP-3 and MP-4) were of high political interest and much discussed in the news, typically people aren't ready to pay any price tag for such product features and therefore they are good candidate for removal from the list of market preferences.

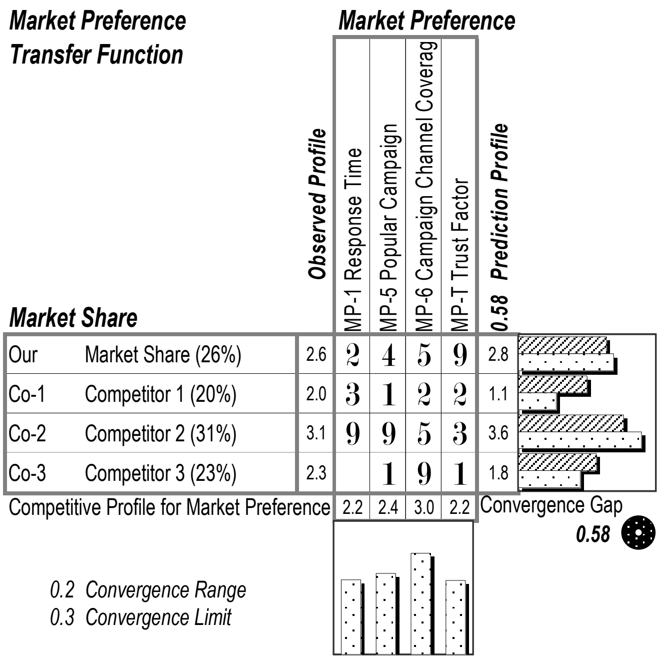

Figure 5: Dismal result when removing some of the supposed market preferences

The result was interesting: the prediction for Competitor 1 and 3 fell below observation, while prediction for Competitor 2’s market share was much too high. That gave a hint that something is missing that increases market share for both Competitor 1 and 3.

In fact, both new competitors made heavy use of the evolving Internet search engines and provided full integration of the customer help desk within their web pages. A quick assessment of the team brought a competitive ranking for MP-N: “New Technology” that reflected the actual market share, see Figure 6, and brought the Convergence Gap down to an excellent *0.05*.

In this case, it turns out that with a modified set – the trust factor and the technology factor added – the Convergence Gap is improved and may better reflect market reality.

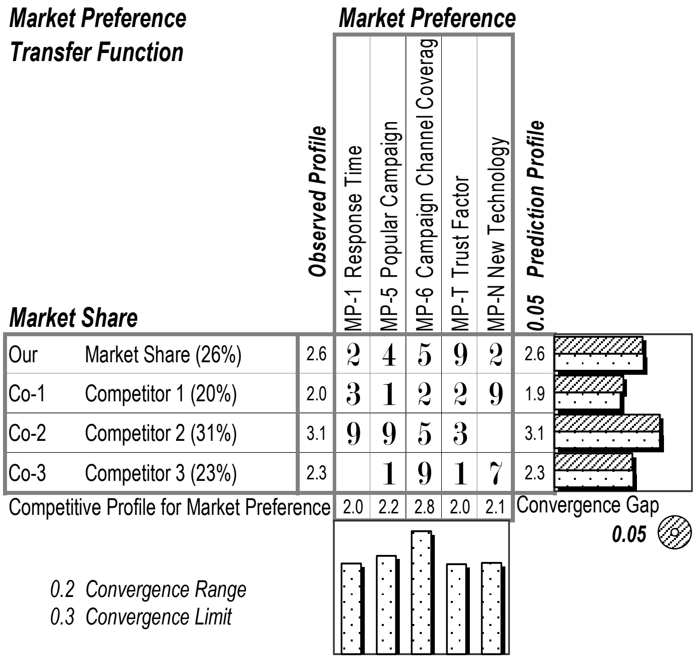

Figure 6: Final result of adjusting the set of market preferences

2.6 Learning from Incomplete Knowledge

Where customers are not readily available to answer questions addressing their needs, Six Sigma offers with transfer functions a nice way of analyzing incomplete information. The Convergence Gap offers a quick means to assess consistency of that analysis; however Six Sigma is no automated problem solver. It requires sound data, domain know-how and excellent QFD practices when predicting market share with Six Sigma.

Clearly, the trust factor is limited in time; as the new competitors consolidate their offerings, its effect will vane and must be replaced by new strong arguments that increase market preference. Recommendations are therefore to watch closely what the competitors do with new technology.

3 The Ideal Situation

3.1 The Lanchester Theory

If the market is in equilibrium, the buying decisions of customers follow a stable pattern. Given a vector of market preferences in the vector space of relevant product features, the transfer function is the matrix of all comparisons buyers made between competitive offerings. This transfer function acts on the market preferences and the results are market shares, again a vector but this time in the vector space of competitive product offerings.

The New Lanchester Theory distinguishes “Strategy of the Strong” for those dominating the market, and “Strategy of the Weak” for those that try to find or create market niches. It deducts a formula drawn from a military model that explains when to use which strategy. For details, see [05].

Ideally, the competitors are distinct only by product features – not by other influence factors such as branding and market image. The target market segment is homogeneous and product features are stable.

The Lanchester “Strategy for the Weak” requires that weak competitors identify areas where they can locally beat the market leader. “Locally” means that they need to focus on some limited market segment.

A formula is derived that basically allows comparing two competitive profile vectors. The so-called “Weapon Strength” E is the ratio between two normalized profile weights (i.e., their vector lengths, see (5)). If E exceeds $\sqrt{3}$ then this competitor is dominant, wins all competitive comparisons and reaches market dominance, see [05].

The New Lanchester Theory has been successfully used under such circumstances for creating world-class products, including software products.

3.2 New Lanchester applied to Help Desk Example

It is tempting to look at the previous example to see what needs to be done for increasing market share. To do this, we calculate the competitive profiles – normally, sum of the competition’s profiles against our own competitive profile.

For the above help desk sample, the comparison of competitive profiles shows that the current market is in perfect equilibrium; nobody has a significant competitive advantage:

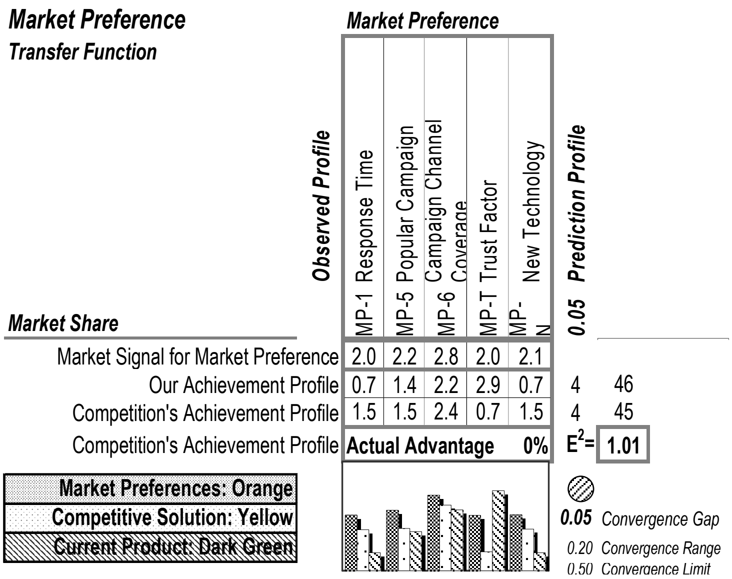

Figure 7: Actual competitive profiles are in equilibrium

The visual profile shows areas for improvement:

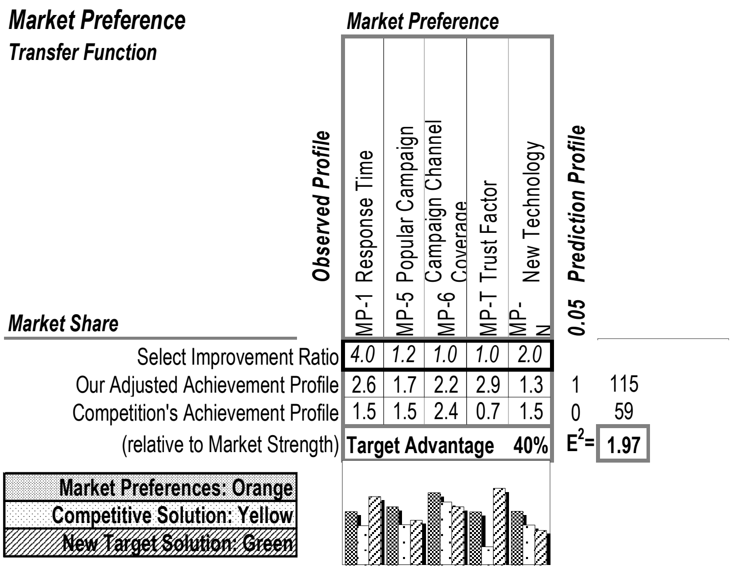

Figure 8: What could be done to win market share

With the New Lanchester theory, it is possible to select topics for product improvement and calculate how well the improved competitive profile of our product matches market preference. Some of the proposed improvements might be costly – especially the increase by a improvement ratio of four (*4.0*) of the MP-1: “Response Time”, and the investment needed into MP-N: “New Technology” as well (ratio *2.0*), but an increase of competitive advantage to 40% (corresponding to E2=1.97) is quite rewarding. According the New Lanchester Theory, 41.7% would guarantee market dominance [05].

3.3 Creating a Winning Product

The other relevant transfer functions, according Figure 2: Deming Value Chain for software product deployment, are

1. **UC** → **MP**: From use case functionality into market preferences – how well does the product meet market preferences? The transfer function $\mathbf{T}_{UC \to MP}$ is used to identify the features needed to meet market preferences.

2. **CtQ** → **MP**: From quality characteristics into market preferences – how well does the product quality meet market preferences, sometimes called “House of Quality”? The transfer function $\mathbf{T}_{CtQ \to MP}$ explains the impact of quality characteristics onto market preferences.

Combining the two transfer functions with the Lanchester Theory, it is possible to predict which features need to be added or removed from the software product in order to gain market share. This is the success prediction input needed for release planning.

The first transfer function defines the functionality that is needed to identify the added or superfluous functionality; with the second, quality characteristics are adjusted to better meet market preferences.

4 Overcoming Difficulties

4.1 Identifying Market Preferences

QFD offers many techniques for analyzing information available on the market – such as verbatim analysis, Google search, and many more. The best reference is the QFD Best Practices [07] drafted by practitioners of the German QFD Institute.

In particular, in the author’s experience, the following approaches provide good results:

- Going to the *Gemba* – observe potential customers how they use the product – is useful for software products even more than for anything else. Software is more easily traceable than hardware, thus software products can easily be traced when used.

- One particular source of information is an ergonomic test – market preferences are more easily detectable when observing what software users are trying to do, than by asking them.

- Another very valuable source of information is building trackers into the software that count how often certain functions or use cases have been activated – care must be taken to get the user's agreement before collecting such information. If doing this, the recommended way is to explicitly ask the user for her or his collaboration before sending collected usage statistics back to the software supplier.

- Asking the product user has the additional advantage that the software product can collect qualified feedback – obviously, such build-in surveys are additional product features and use cases that need to be build into the product.

- Watching evolving technology is a very valuable source for potential market preferences as well – they might point into the future but when correlated with business value they allow reliable predictions.

- Another approach is with classical marketing. If markets are well defined and some customers willing to provide information, a sensing group or a market survey can help.

The preferred selection depends from the Deming Value Chain used for building the software product.

4.2 Using the IT Product Compass

An easy way of detecting unknown market preferences is using some standard model – e.g., the IT Product Compass published by G. Herzwurm and W. Pietsch, p.22 [08].

A basic set for selecting market preference topics for investigation in transfer functions consists in this example by the following:

- Development
  - Product Life Cycle status (new product, or refurbished…)
  - Target Definitions (target market, target customers, target problems)
  - Training Needs (depending upon roles, e.g., user, superuser, administrator, …)
  - Installation Ease (interoperability, interfaces, standards, constraints, …)

- Operations
  - Data Security (privacy, redundancy, disaster recovery, …)
  - Operational Ease (service dependency, autonomy, availability, …)
  - Administration (account management, login management, …)

- Application
  - Target Users (office-base, home-based, mobile, …)
  - Consultancy Needs (skills availability, …)
  - Helpdesk Support (channels, competency, response time, …)

- Service and Support
  - Incidence Management (non-conformities, maintenance, …)
  - Defect Prevention (release cycles, regression testing, …)
  - Preventive Maintenance (new feature management, …)
  - Corrective Maintenance (hotfixes, support interventions, …)

This set of standard market preferences topics serve for analyzing market share observations, if none more specific are available. It allows benchmarking software products that do not share common functionality.

4.3 Filling the Matrix

Having a set of potential market preferences is one problem solved; however, setting up the transfer function is not done yet. The transfer function is usually represented as a correlation matrix, i.e., a matrix whose cells indicate the strength of coupling between the respective $\underline{\mathbf{x}}$ and $\underline{\mathbf{y}}$ component. We have seen that methods exist to measure the matrix components.

Once candidates are selected for the market preference topics, support cases are the most valuable source of information for the **FN** → **UC, UC** → **MP** and **CtQ** → **MP** Transfer functions, see below in 4.4. Trackers, as explained in section 4.1, can also be used to fill in the correlation matrix, since **FN, UC** and **CtQ** are stable at least within one product release.

See [06] for a suggestion how to measure Deming Chains such as **UC** → **MP** when developing software. Note that usually there is functionality in the product that does not contribute to any market preferences topic at all – such as housekeeping functions, security checks, etc., however, market preferences change fast.

4.4 Analyzing Support Cases

A wealth of information is available for most of the companies producing software: support calls. Support cases tell more about changing market preferences than anything else. Customers tell the support people what they are trying to do and cannot achieve, for some reason.

Support calls most often address the **FN** → **UC, UC** → **MP** or **CtQ** → **MP** Transfer function, sometimes also **MP** → **BO**, when users try to explain their business objectives to the help desk. Support data primarily fills the matrix. Collecting support case data successfully involves classifying them into the applicable Deming Process, train support personnel to ask the right questions, and set up the respective data collectors.

For most software product suppliers, this is most rewarding data source and probably the best investment into market research. With such data, trends towards new market preferences are detectable using techniques shown in section 2.5.

4.5 Using Traditional QFD Workshop Techniques

If measuring the matrix components is difficult, traditional QFD workshop techniques can help to “guess” the correlations factors if they aren’t measurable. The Convergence Gap is helpful for such workshops as well since even if the accuracy of matrix correlation is uncertain, the uncertainty can be measured – and in fact, it must be measured.

4.6 Closing the Convergence Gap

If the New Lanchester Transfer Function shows a large Convergence Gap, it hints at the possibility that relevant Market Preferences remain undetected. As in example 2.5, additional topics can be constructed from the matrix correlation values observed.

Sometimes it helps reformulating the preference topic statement; sometimes it should be split into two for better modeling the buyer’s behavior. The criterion is orthogonality, i.e., the preference topic statements should not be dependent from each other. In the competitive assessment, it should be possible to change one topic’s evaluation without affecting others.

However, if this trial and error approach does not lead to tangible results, there is another check that can be performed. Let $\underline{\mathbf{y}}$ denote the observation; a rectangular AHP matrix must exists[5] that has $\underline{\mathbf{y}}$ as its result. To construct this matrix in practice is not difficult; however, the pair-wise comparison involved in its construction will point the team towards the relevant market preferences.

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[5] The AHP matrix is triangular; its sub-diagonal part being completed by reciprocal values. Such a matrix has Eigenvectors, see the Perron Theorem in [10], and its application to Six Sigma in [06].

5 Experiences

GMC Software Technology, a world-class provider of personalized customer communication software (Direct mail, bills, statements, etc.) uses New Lanchester Theory to steer its 30% – 50% yearly growth and outperform its competition. New Lanchester Theory was used for selecting new features to be included in new releases. Using the controlled approach, it did not only allow to win market share, but also to avoid winning too much market share, in selecting new features such that GMC remained able to manage its growth.

Since 2008, GMC has become world leader in customer communications software, and the New Lanchester Strategy had being turned from the “Strategy of the Weak” to the “Strategy of the Strong”, thus the need to be more innovative than the competition and block possible market niches for new competitors.

Some details of GMC’s approach have been published in [04]. Other experience reports are difficult to find, as New Lanchester Theory might be used in corporate strategic decisions that are not widely communicated.

6 Conclusions

Statistical methods, including the Eigenvector theory, open a wide range of application possibilities to product management and product improvement. Finding the best combination of traditional product marketing and Six Sigma approaches is not easy, and experiences are not widely shared.

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