# Value Assessment of New Product Innovations

by

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Submitted to the System Design and Management Program
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## Abstract

In the commercial industry, an investment in a new innovation can make or break a company. In order for the new innovation to succeed in a competitive marketplace, it must deliver value to its stakeholders. Companies are thus rewarded to assess the value an innovation will deliver to its customers early in the design process. This thesis provides a framework to measure the potential value a new innovation will deliver to consumers based on scoping the project. The framework provides details on creating a model based on the Analytical Hierarchy Process (AHP) by establishing a hierarchy of customer objectives. The application of the framework is then applied to a large company developing two new innovations.

Two interesting facts arose from the study. First, the value assessment model can be fractionated to evaluate how new products are valued by multiple market segments. A company can use this information to align a new innovation with a brand segmentation and develop an appropriate strategy to launch products. Secondly, this methodology has been shown to work on incremental innovation and non-traditional products which expand the customer base. The methodology does work when applied to radical innovation which overturns existing value structures and changes the market dynamics.

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To all my friends I have made in the SDM program, I wish you the best of luck in your future endeavors. I know you will succeed at your goals with the breadth of experience we have from the SDM program.

Finally, I would like to thank my family for their patience and support. They have encouraged me to seek my dreams, even if it means sacrificing my time with them. For that I am eternally grateful. Laura, I cannot thank you enough for your encouragement and support. To my parents, words cannot express the gratefulness for the sacrifices you made to give me a great life.

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# 1 Introduction

This thesis will guide the process of creating a model to accurately reflect how users value new innovation in a marketplace. A literature review will demonstrate what is value as well as a review for two sides of a new product launch: from the side of the developing company, and from the side of the consumer. The review will outline how some have identified customer objectives and create engineering attributes to meet their goals. The side of the customer will examine how individuals value their objectives. Most importantly, how they evaluate multiple objectives in order to make a decision.

The literature review will feed into the framing of a solution to address the needs expressed in later in this section. The detailed process will be laid out before starting an application of the framework to an actual marketplace. Finally, the model will be applied to two new development products to assess their potential value to consumers.

## 1.1 In Context of New Product Development

Countless hours have been spent streamlining processes in product development to create efficiencies, reduce cost, and reduce time to market. The product development world has made use of these advances such that the marketplace becomes competitive with new products and technologies which are delivered faster, cheaper, and with increasing quality.

Yet, simply delivering a new product to the marketplace does not guarantee success. Moreover, it is not enough to deliver a product under budget, on time, and with the appropriate scope. Rather, success of the system is based on externalities, such as customer perception, current events, and value structures, which are all vague at best. While cost, schedule, and scope can derail a project, the customer is the final judge of a product's success.

The consumer product industry is plagued by this phenomenon. System designers are constrained by customers who are unable of expressing their needs for new innovations, not to mention their inability to articulate a hierarchy of needs. Yet this is not the fault of the customer. Leondard and Rayport (1997) state customers cannot drive new products because they are constrained by their limited training and ability to describe potential solutions to their needs. In fact, they may have a need that they do not realize until it is satisfied.

Even if a customer was able to conceptually express their needs, each individual would have a different prioritization which would result in a unique hierarchy. Although there may be overlaps in the hierarchies, the differences fractionate the market into multiple segments. The fractionated market places a strain on a company developing a new product. They must determine a product's robustness to multiple segmentations versus the value to individual segments to adopt an appropriate strategy to appeal to its customer base.

The ambiguity which surrounds customer needs is a cause for concern to new product developers. Gourville (2006) has researched this issue and its effect on new product releases. He estimates the failure rate of new consumer products to be 40% to 90%. This fact is directly correlated to a psychological disconnect between new product companies and their targeted customers.

In order to improve success, companies try to focus their efforts on delivering value to their customers by placing them at the center of their strategy. Lou Gerstner, credited for the successful turn-around of IBM during his tenure as CEO in the 1990's, followed a similar strategy. He claimed that his key strategic decision was:

> *"...Drive all we did from the customer back and turn IBM into a market-driven rather than an internally focused, process driven enterprise"* (Gerstner, 2002)

His drive to focus on the customer and their needs redefined IBM and enabled it to become a leader in new segments such as software and services.

There is sufficient evidence to support the criticality of creating new products to meet, or sometimes to create, a customer need. The success of a new innovation is dependent on the ability of the designers to identify and prioritize needs in order to create new products which creates value for the customer.

In new product development there are research questions which this thesis will attempt to address. They are:

> *When evaluating a new product, how do consumers set objectives, and more importantly, how do they use those objectives to make an evaluation?*
>
> *How do we measure the preferences of a marketplace to determine the relative value of a new innovation to a customer base?*

## 1.2 In Context of the Product Development Process

The amount of uncertainty associated with innovation is a cause for concern to developers. The cost of development for companies can be significant if a product fails to live up to its sales forecast. Therefore companies are incentivized to deliver a product which maximizes value delivery to the customers while minimizing costs of development.

Development costs are incurred throughout the entire design process. To understand where costs are incurred, a generic product development process (PDP) can be used to identify stages of product development. A generic version of PDP can be divided into five phases: conceptual design, preliminary design, detailed design and development, production, and product use. This is shown in Figure 1.

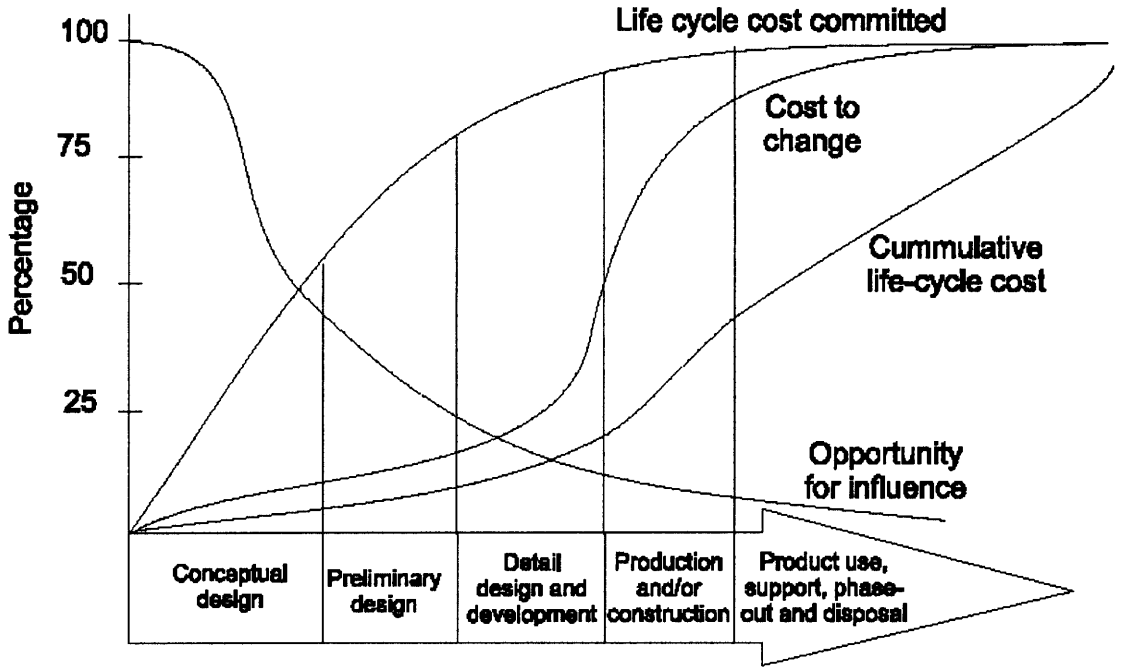



**Figure 1:** Cost associated with sequential phases of a PDP (Adapted from Blanchard and Fabrycky, 1998:37, 561 and Blanchard 1998:82)

In product development, there are two different types of costs: cumulative life-cycle costs and committed costs. Cumulative costs are simple; they are how much the development team spends during that particular phase. Committed costs are the costs which are designed into the product during the phase and are to occur at a later time.

The issue at stake is a separation in time of a significant portion of the committed costs to when the value of a product is determined. Typically a new product is placed in front of the consumer after the detailed design phase to incorporate feedback and measure the value delivered to consumers. By this time, roughly 85% of the costs are already committed, resulting in missed opportunities to potentially capitalize on a new discovery.

The separation in time between actual and committed costs is a disadvantage to developers. An improved process would front load the design process with an evaluation of the potential value delivery based on the needs, or objectives, of the consumer. A front loaded value metric could eliminate the shot in the dark approach some companies are forced to take with new technologies and thus eliminate the risk by ensuring customer value is maximized.

This type of evaluation would measure the potential value delivery. The actual value delivery of a product is dependent on the embodiment of the architecture and the success of the product to meet customer needs. For example, value is destroyed by creating a complex user interface that intimidates customers by its use context. Therefore an initial evaluation can be made based on the customer needs, or objectives.

## 1.3 In Context of the Corporation

So far, this discussion has been about one product. In reality, a corporation has a portfolio of products, each with multiple design alternatives. It is important for the corporation to know the contents of their innovation pipeline, prioritize products, and deliver these products in a timely manner.

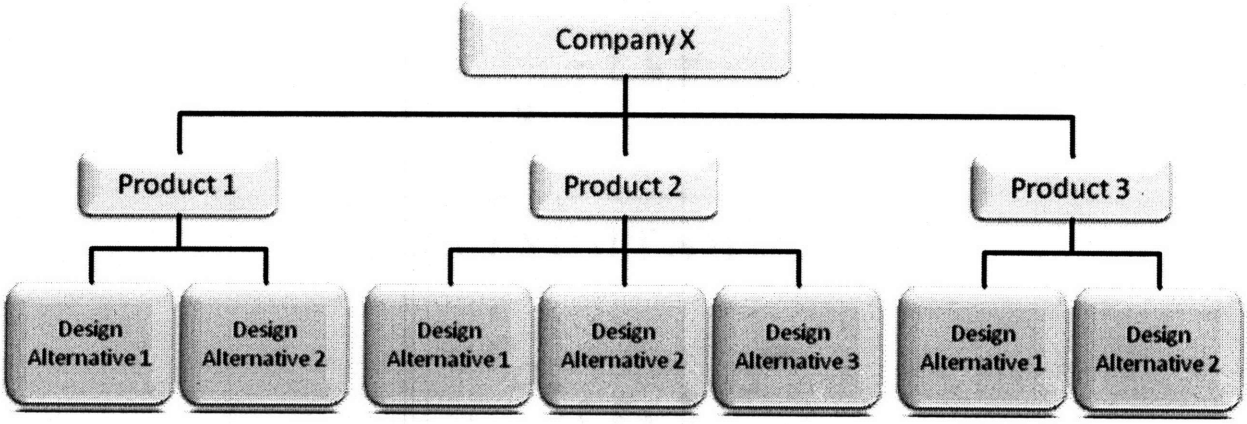



**Figure 2:** Structure of a Company's New Product Portfolio

Speaking in context of the workplace, there are limited resources to invest in products, as shown in Figure 2. Capital is limited by the budget and man power is constrained by the workforce. Opportunity costs are a result of these constraints. Fast tracking project x to the marketplace, results in a loss of opportunity to capitalize on project y until a later point in time.

It is up to the corporation to prioritize projects to reduce opportunity costs, mitigate risk, and deliver the most potential value to the customer through an optimal selection of projects. Sometimes, decision makers must make these decisions based on incomplete information, or even a hunch. Data is not always available to quantify the right or wrong decisions.

In reality, the decision should be made with the context of the needs of the customer. The decision maker needs quantifiable data which ranks consumer needs in a hierarchy.

In context of the corporation, specific research question will be addressed in this discussion. They are:

> *Can the front end value evaluation also measure the potential value to multiple market segmentations?*
>
> *How can this technique be used to align a technology with a brand strategy?*

## 1.4 In Context of the Enterprise

In face of the large odds against new and innovative products, companies must take appropriate actions to ensure their successful implementation. They must gather consumer insights to identify needs. These needs should be used as a framework to guide the process of designing new products from start to finish. The framework must be robust to speak for multiple individuals, each with their own interpretation of value.

In order to address the customer's objectives, companies must invest in new innovations. Given the success rate of new innovations, it can be costly to a company if not done properly. Therefore, pushing the valuation process of new innovations up in the design process can decrease the risk of investing in a potential failure, and provides efficiencies in downstream activities by eliminating some of the ambiguity of the scoping process.

# 2 Literature Review

The topic under discussion has roots in various social sciences. A literature review was performed to explore each of these categories and will be discussed in the following subsections. These subsections include value, value creation in product development, utility theory, prospect theory, and market segmentation.

## 2.1 Value

There are several definitions from multiple sources as shown in Table 1.

**Table 1:** Value definitions from multiple sources [adapted from Chase (2001)]

| **Value Definition** |
|---|
| Value is the appropriate performance and cost. (Miles, 1961) |
| Lowest cost to reliably provide required functions or service at desired time and place and with the essential quality. (Mudge, 1971) |
| Value is function divided by cost. (Kaufman, 1985) |
| Value is the potential energy function representing the desire between people and products. (Shillito & DeMarle, 1992) |
| Value is a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer. (Womack & Jones, 1996) |
| The additional functionality of a product normalized by the cost of the additional functionality, or simply function divided by cost. (Cooper & Slagmulder, 1997) |
| Value is a measurement of the worth of a specific product or service by a customer and is a function of:<br>(1) Product's usefulness in satisfying customer needs; (2) Relative importance of the need being satisfied; (3) Availability of the product relative to when it is needed; (4) Cost of ownership to the customer. (Slack, 1998) |
| Value is anything that directly contributes to the "form, fit, or function" of the build-to package or the buy-to package<br>• Form: Information must be concrete format, explicitly stored<br>• Fit: Information must be (seamlessly) useful to downstream processes<br>• Function: Information must satisfy end user and downstream process needs with an acceptable probability of working (risk) (LAI, 1998) |
| [Value is] balancing performance, cost, and schedule appropriately through planning and control. (Browning, 1998) |
| [Value is] a system introduced at the right time and right price which delivers best value in mission effectiveness, performance, affordability and sustainability and retains these advantages throughout its life. (Stanke, 2001) |

There are synergies which arise from each definition of value. Each definition makes reference to the fact that value is created when the amount of an acquired benefit exceeds the cost of acquisition. The amount of value created in an exchange of goods, services, or money is simply the difference between the acquired benefit less the cost of the benefit. This is illustrated is below.

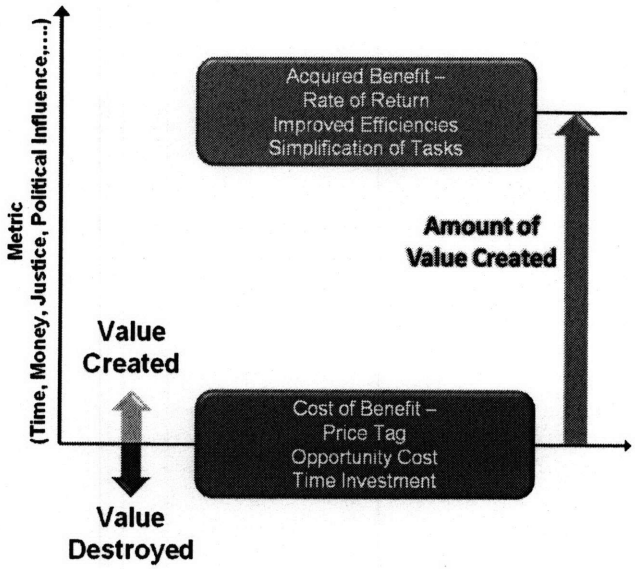



**Figure 3:** Value Creation

When the acquired benefit exceeds the cost of the benefit, value is created. The corollary is if the acquired benefit is less than the cost of the benefit, value is destroyed. Researchers suggest to simplify the metric to incorporate the two measures into a ratio of acquired benefit over cost. This implies when the ratio is greater than unity, value is created, and as the ratio increases, the value proposition of the system in question is emboldened.

To take a step back, value is created on multiple levels of the human mental and physical psyche. According to Mudge (1971), in 350 B.C, Aristotle laid out a framework for areas to deliver value. His taxonomy still holds true today. His framework outlined seven areas for value delivery:

- Moral – pertaining to ethical behavior.
- Aesthetics – pertaining to beauty, attractiveness, elegance, etc.
- Social – pertaining to societal relationships

- Political – pertaining to government or public affairs.
- Religious – pertaining to the worshiping of a superhuman power.
- Judicial – pertaining to the judgment and administration of justice.
- Economic – This category was further decomposed into :
    - Use Value – properties that accomplish a use, work or service
    - Esteem Value – properties that make ownership of an object desirable
    - Cost Value – properties which are the sum of the labor, material, overhead, and other costs required to produce something
    - Exchange Value – properties of an object that make it possible to procure another item(s) by trading

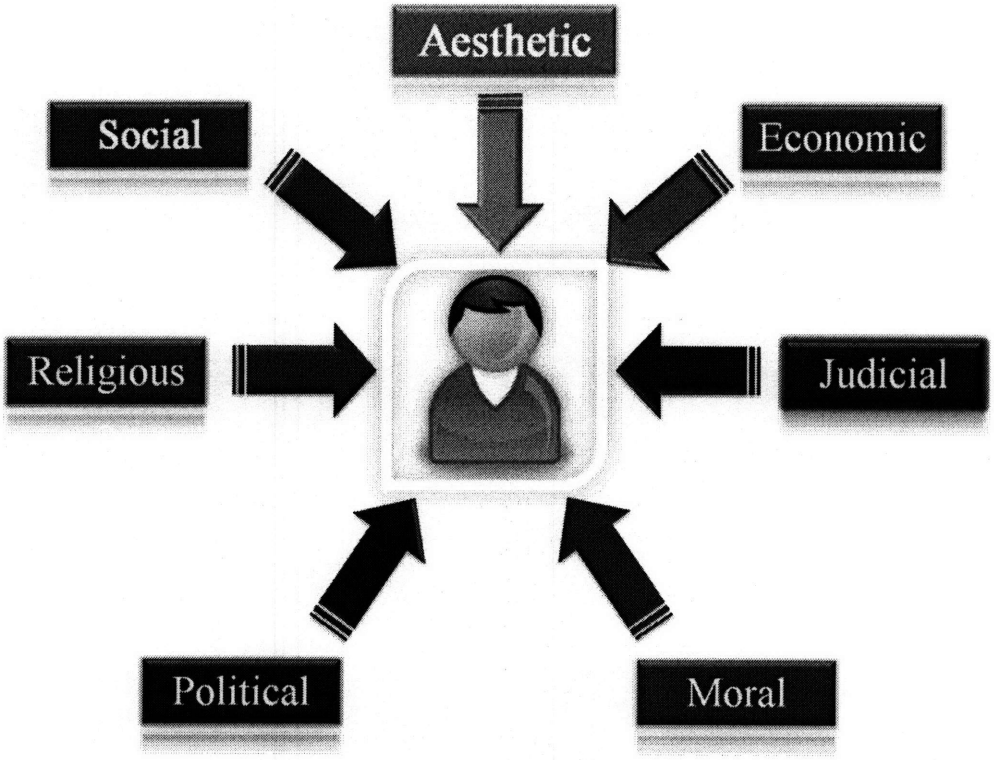



**Figure 4:** Taxonomy for Value

Of these seven areas of the human psyche, only the economic area is directly measurable. Thus, most of the research on value delivery has focused on this section of the taxonomy. The results

include metrics such as rate of return, net present value, economic value added, along with a laundry list of others.

Thus a question is raised, what are the units of value? An obvious objection is raised due to the subjectivity of assigning values to intangible attributes. Yet following Aristotle's taxonomy, multiple units could be justified as a reasonable approximation, and ultimately depends on the situation. For simplicity, monetary units have been the primary usage in quantitative studies. But other metrics such as time, political and social gains, and justice, are all supported by the framework. In today's marketplace, the cost of most benefits is expressed in a currency, which furthers emboldens the push towards financial metrics.

In fact, a division of engineering exists based on this fundamental principle of assigning a monetary value to a function of a particular system. This engineering practice is known as value engineering, or delivering system functionality per requirements at the lowest cost.

*Concluding Thoughts:*

Value is a concept which has been debated for centuries, and continues today. More importantly how value is measured when there are potentially unlimited avenues to measure. The cause for tension arises from assigning an objective value to a subjective, intrinsic characteristic. Thus there is a trend towards assigning a monetary value to system features as a means to justify the cost, which by no means is a simplistic task. Yet even assigning a monetary value induces more complexity due to the human psychological perspective of valuing gains and losses. This will be discussed in a later section.

There are several key ideas in this section which should shape the framing of a model. The ideas are:

- Value is acquiring a benefit based on the cost of acquisition.
- There are several ways to deliver value based on the taxonomy. But each area of the taxonomy measures value on a different scale. Hence a model should classify all seven areas of the taxonomy to one measurement scale to systematically incorporate all of the factors.
- Monetary metrics exist to assign a monetary value to a function to assess the value. Yet this includes some bias and ambiguity. A model should aim to eliminate these problems.

## 2.2 Value Creation in Product Development

The underlying assumption from the previous section is people have needs, or objectives. These objectives can be met by new products and/or services. By creating systems which meet these needs, and are cost effective, creates value. The amount of value is dependent on the predisposition of the stakeholder and what need is being met.

There are advantages of placing customer needs at the center of the design process. The Voice of the Customer (VoC), as referred to by Clausing (2007), must be used to set the goals of the system, define objectives, and make decisions. Clausing (2007) accurately portrays the deployment of VoC as a two dimensional process, horizontally and vertically through the phases of development. Deploying horizontal across the phases of development, such as planning, design, and operations ensures the delivered product aligns with the needs of the customer. Vertical deployment of VoC ensures a focus to customer needs throughout multiple system levels.

Clausing further goes on to explore Quality Function Deployment (QFD) as a means to ensure the successful deployment of VoC. QFD has been used in industry as a dependable method to manage this task. One of the largest benefits to QFD is the correlation and dependencies of customer needs to engineering specifications and requirements. The output of a QFD results in a convergence on a matrix representation of the customer needs and engineering specifications. Although, an accurate translation from the VoC to the EoE (Ear of the Engineer) is difficult at best.

While the transition is important, a lot of merit is warranted in a deep understanding of the customer's objectives. Each objective has a different interpretation to customers. This non-physical representation can elicit a response based on the individual's value structure. Kano (Walden, 1993) suggests a classification system where not all needs are equal. To simplify his interpretation, needs are defined by three broad categories:

- Must-haves – referring to system attributes which are essential to the incorporation of the new product or service. These are the price of a ticket in order to play in the current business ecosystem.

- Satisfiers – referring to increasing stakeholder satisfaction from increasing performance of a system attribute.

- ❖ Delighters – referring to a stakeholder need which if increased a small amount results in a large return on customer satisfaction. Most often this is a need which a stakeholder did not realize until they operate the system.

A classic representation of this characteristic is shown below.

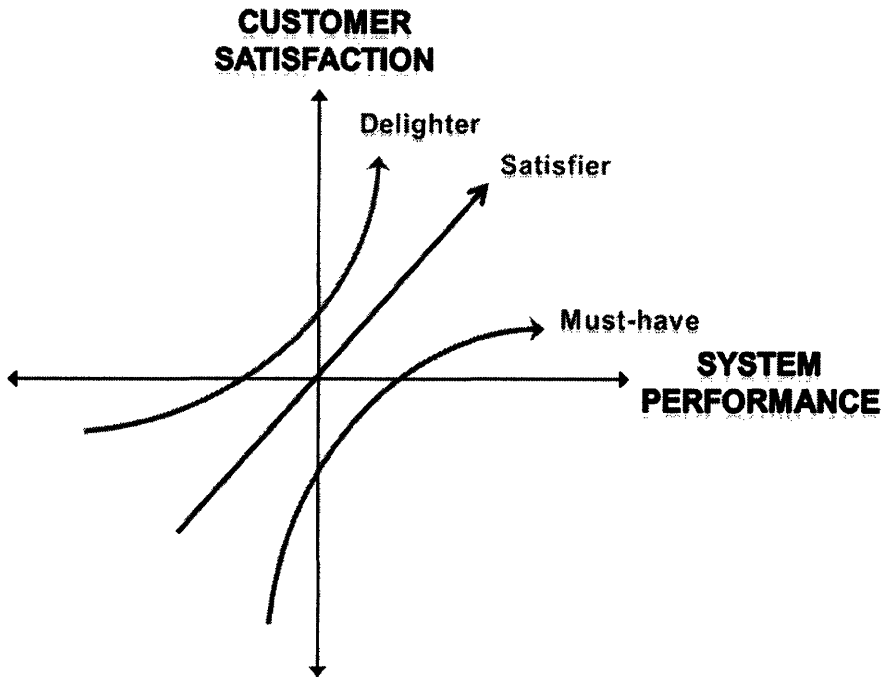



**Figure 5:** Classic Kano Model of Classes of Needs [adapted from Walden (1993)]

Once a deep understanding is obtained of the critical objectives of a customer, or stakeholder, the project enters a trade-off space. Scoping the project requires trade-offs of objectives in order to satisfy each stakeholder. Boehm (2006) postulates a theory of the only way for an enterprise to succeed is to create value for every success critical stakeholder. Upon further elaboration, they claim this theory demands the execution of four additional requirements:

- ❖ Dependency Theory requires identifying all major success-critical stakeholders.
- ❖ Utility Theory requires understanding what a success critical stakeholder wants.
- ❖ Decision Theory requires identifying how needs translates into decisions.
- ❖ Control Theory requires controlling value creation during change.

In product development, there is a special challenge to assuage the needs of each stakeholder. Cameron, Crawley, Loureiro, & Rebentisch (2007) have created a methodology to map stakeholders, their needs, and who satisfies those needs in a closed system format. Their methodology creates a pictorial diagram to identify the flow of value from multiple stakeholders based on their individual objectives.

*Concluding Thoughts:*

Designing new products and services is a complex task. Products succeed if and only if they address the needs of all stakeholders to create a win-win strategy. For the purpose of this dissertation, only one group of stakeholders will be analyzed, the customer. By all means, this is not a simplification due to multiple customers, each with different needs, different objectives, and different value structures.

This section covers diverse topics regarding the creation of value in new product development. Most of the information covered was in regards to the methodologies for companies to ensure value delivery, and in turn a successful system. The key ideas which will affect the model are:

- The success of a system is dependent on multiple stakeholders. The model to be generated represents one group of stakeholders. Therefore, the results of the model must be incorporated into trade-offs with other stakeholders in order to ensure success.
- There are methodologies to identify customer objectives. Correctly identifying customer objectives leads to a high degree of resolution in the model's output. Tools such as QFD have been shown to scope projects based on these objectives. The scoping process will aide the assessment of potential value delivery of new products.
- Customers value their objectives differently. A Kano model provides information on a classification system of how a customer value objectives. Identifying objectives which are delighters, satisfiers, and must haves is a significant advantage in product development.

## 2.3 Utility Theory

Utility theory provides an avenue into how people value a particular system. For each system there are a set of attributes to describe the system's function and/or behavior. Specifically, these attributes align with the objectives of a stakeholder, which makes the system in question desirable. One of the prominent breakthroughs was Multi-Attribute Utility Theory (MAUT) proposed by Keeney and Raiffa (1976). This theory provides a means to evaluate the utility of

individual objectives, and then combine them for an overall estimation of utility. The underlying principle to MAUT is the evaluation process of humans is based on multiple inputs and stimuli. These stimuli are interpreted, evaluated, and then combined.

Before further discussion on this topic, a discussion on how an individual processes information is warranted. Catanzaro (2006) provides an interesting discussion on this topic of how external stimuli are processed to shape the response of an individual as shown in Figure 6.

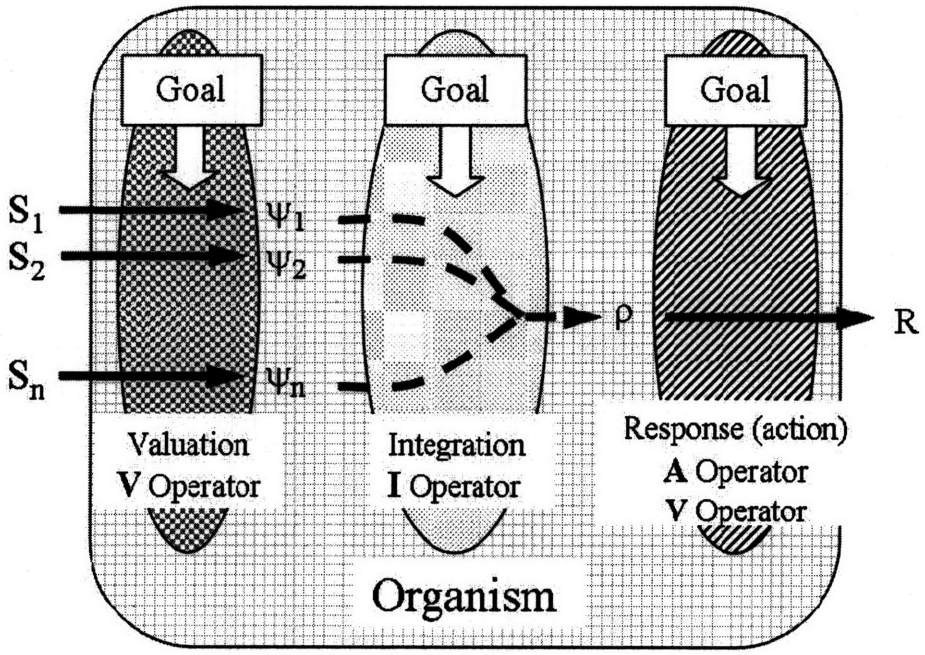



**Figure 6:** The unobservables of information processing [Catanzaro, 2006]

During his discussion, he notes that Anderson (1996) proposes the characteristic of purposiveness to describe Information Integration. This draws on the principle that human behavior is goal oriented. This basic principle is the foundation for the possibility to create a one dimensional metric, through cognitive algebra, to represent the thought process of evaluating multiple inputs.

From Figure 6, $S_n$ represents the stimuli from the external environment. Organisms observe these stimuli and translate them into psychological representations, $\Psi_n$, due to an internal value operator.

The psychological representation undergoes an integration operator to unify the representation into a single internal response, ρ. There is several published work to suggest this operator is a

simple algebraic interpretation such as a multiplicative or additive function. The final step is the translation of the single internal response into an observable response.

This framework provides interesting insights into how organisms process information and make decisions. They are exposed to multiple stimuli, or attributes, to combine this information into a single internal representation. The guiding principle is the idea that these mental representations are guided by the goals set by the individual. MAUT operates along these same principles. One of the fundamental principles of MAUT is assigning various utility functions, U(x), to attributes of a system, x, which are rolled up into one utility function.

$$U(X) = U(x_1, x_2, ...x_n)$$

Keeney and Raiffa (1976) provide basic definitions, which guide the context of future discussions.

- Objective – An objective is an indication of direction of which a decision maker will be better off. An example is a technology firm which sets an objective to increase quality of its product.

- Goal – A goal is different from an objective because it indicates the level of accomplishment which is desirable. Therefore a goal is the measuring stick for achievement. For example, a goal for the technology firm is to produce products with 95% quality.

- Attribute – An attribute is a measurement scale for an objective. For example, an attribute for the technology firm could be the number of defects per part. They further go on to explain that an attribute should be comprehensive and measurable. Comprehensive implies knowledge of the level of an attribute creates comprehension of the extent to which an objective is realized. Measurable implies two important characteristics. First, for each alternative, it is possible to create a probability density function for the possible levels of the attribute. Secondly, it is possible to assess the preference of a decision maker for multiple levels of performance.

- Proxy Attribute – A proxy attribute determines the extent to which an objective is met, but it does not directly measure the objective.

The first step in utility theory is to identify the objectives of a customer. By no means is this a simple task to determine a set of objectives which accurately portray how a system will deliver value. Keeney and Raiffa (1976) offer assistance with some desirable properties of the objective set. The properties are:

- Completeness – The objective set should cover all important aspects of the system in question. If an objective is missing, a section of the value spectrum will not be quantified.

- Operational – The objective set should weigh on the customer in the analysis and decision making process. Without this property, a customer is not capable to comprehend what is at stake and the potential to make trade-offs.

- Decomposable – Making a decision based on an objective set becomes complex with increasing the number of attributes. Simplifying the process by breaking down the attribute set into parts reduces the complexity of the decision process.

- Non-redundant – One objective should not be counted twice in the process, so elimination of redundancy accurately reflects the decision making process.

- Minimal set – Constraining the dimension of the objective set, while maintaining the previous properties, reduces the complexity.

Further definition is now warranted on the previously mentioned combinatorial utility function. According to Keeney and Raiffa (1976), this utility function can be an additive or multiplicative function, although an additive function is more frequently utilized. Therefore, the combinatorial utility function can be shown as:

$$U(o_1, o_2, ...o_n) = \sum_{i=1}^{n} U_i(o_i)$$

This representation is a simplification due to the elimination of potential interactions. Meaning the utility of one objective, U(o), is not dependent on the level of another objective. Hence, a critical requirement for this assumption is preferentially independence of objectives within the set.

*Concluding Thoughts:*

This section provides broad perspective on human evaluation of alternatives based on multiple inputs. The foundation of this perspective comes from the field of psychology, but has been elaborated by engineers, to show how organisms take in information, weigh, combine and make a decision. According to MAUT, these multiple inputs can be represented through an algebraic operation to combine weighted objectives for a total utility.

Several theories have been built on top of this basic equation to improve the accuracy of the decision making process. One of the most promising theories is Prospect Theory proposed by Tversky and Kahneman (1981), which will be discussed in the next section.

This section has covered psychological concepts that will play an important role in the development of a model of potential value. The key ideas which will affect the development of a model are:

- Organisms observe multiple stimuli and process that information in a non-physical way. The processing of information is driven by the organism's individual goals. Therefore, the model should test multiple inputs, as well as multiple goals for the inputs.
- MAUT provides an algebraic representation of the work described by Anderson (1996). Multiple objectives are combined and summed in an additive function.
- Definitions were provided to give a clear understanding of an objective, a goal, and an attribute. The model will have to test the objectives and goals of each individual.
- Keeney and Raiffa (1996) provide a list of characteristics when selecting an attribute set.

## 2.4 Prospect Theory

Previous sections have discussed how individuals process information to make decisions. This information is useful and informative, but Tversky and Kahneman (1981) has shown the decision making process is also dependent on how the evaluation is framed. Their work on Prospect Theory has been demonstrated in "The Framing of Decisions and the Psychology of Choice".

Before further discussion, a brief summary is warranted on an individual reaction when presented with risk during an evaluation. Keeney and Raiffa (1976) discussed two profiles to classify how an individual reacts to uncertain outcomes. The first profile is a risk adverse behavior in which the individual behaves conservatively. A depiction of their utility function would be a concave function with increasing performance. For example, say a risk adverse

person has $10. Their utility will greatly increase with an additional $20. Now consider they have $1,000. Their utility function will increase with an additional $20, but not as much as the first scenario. They value their current assets, and are less likely to risk that loss at the expense of a gain. The second profile is a risk prone behavior in which the individual behaves non-conservatively in an attempt to increase their satisfaction. A depiction of their utility function would be a convex function with increasing performance as shown in Figure 7.

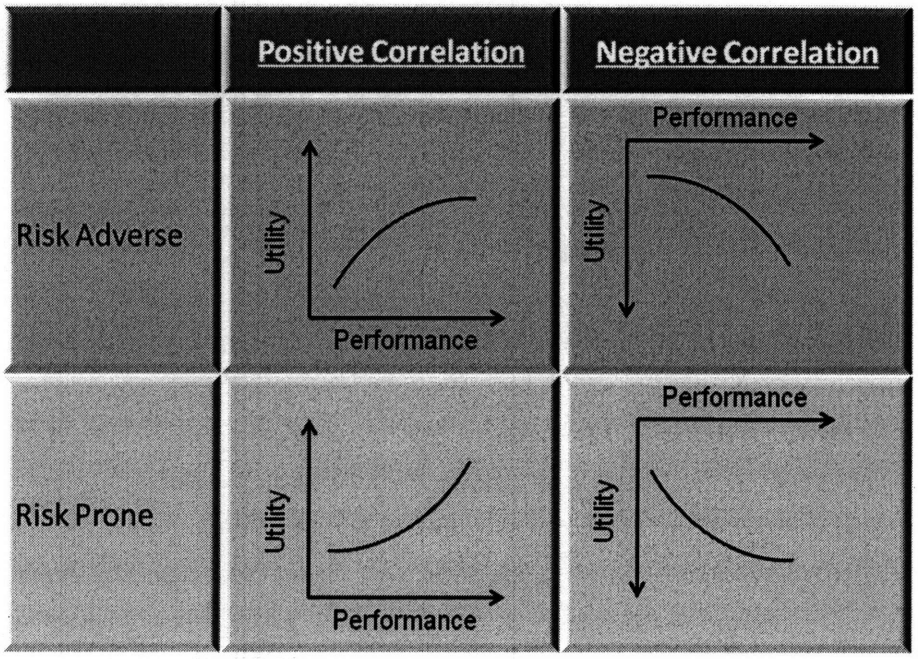



**Figure 7:** Risk attitudes when presented with a loss or gain

Tversky and Kahneman (1981) stress the idea of rationality in the process of organisms making evaluations. Their definition of rationality states that evaluations should "satisfy some elementary requirements of consistency and coherence". Their research has shown that organisms violate rational evaluations when the problem is framed in a different context. This means that an individual may evaluate the same choice completely differently based on how the problem is phrased.

From their research they present an interesting study. They propose a question to 152 individuals and ask which option they prefer. Their scenario is described below along with the responses.

*Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:*

*If Program A is adopted, 200 people will be saved. (72% selected this option.)*

*If Program B is adopted, there is a 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved. (28% selected this option.)*

The popular choice was a risk adverse decision where individuals prefer a guaranteed gain rather than a risk of potentially equal outcome. To test the rationality of answers, a second group of 155 individuals were tested using the same introduction but different wording to the options. The options for this survey were:

*If Program A is adopted, 400 people will die. (22% selected this option.)*

*If Program B is adopted, there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will die. (78% selected this option.)*

Even though the outcomes are equal, the popular choice was risk prone, simply due to the evaluation being framed in a different context. This tendency has been shown in multiple case studies and examples. The pattern is evident that when decisions involve a gain, individuals are risk adverse, and when presented with a loss, individuals are risk prone.

They postulate through Prospect Theory that a value function is should be S-shaped. This shape demonstrates the example shown above, when an individual perceives a gain, they act in a conservative manner. Yet presenting the individual with a loss causes a non-conservative manner as shown in Figure 8.

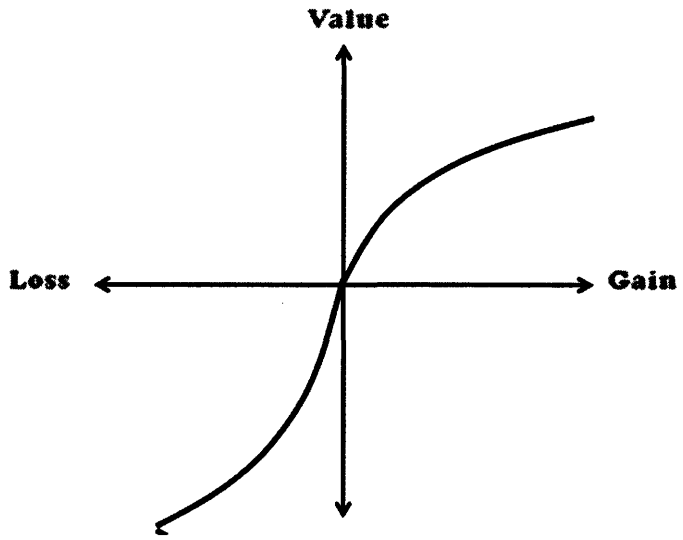



**Figure 8:** Shape of a value function based on Prospect Theory [adapted from Tversky & Kahneman (1981)]

This sets the stage for discussion on how consumers evaluate new products in the marketplace. Gourville (2006) identified four characteristics on how individuals respond when presented with alternatives. These characteristics are:

- ❖ People make subjective, or perceived, value judgments rather than objective, actual value.
- ❖ A reference point is used to relatively evaluate alternatives. This reference point is typically their current solution to meet the need in question.
- ❖ Based on the reference point, people see shortcomings of alternatives as losses and improvements in alternatives as gains.
- ❖ Finally, people are affected far more by losses than by gains of equal value. According to Kahneman and Tversky "losses loom larger than gains."

The psychology of change leads to consumers irrationally over-valuing their current assets. Gourville (2006) lays out guidelines of why consumers over rate their current products. The first reason is "the endowment effect". He elaborates that consumers value their current assets and what they have to sacrifice greater than what they could obtain. The second reason is what he calls the "status quo bias". This idea represents that individuals tend to stick with what they currently own rather than switch, even with the existence of a better alternative. Researchers have also found that this bias increase based on how long the individual owns the asset.

The result of Gourville's (2006) research is consumers tend to over-value their current products by two to three times. He also theorizes product development firms over-value their products by equal amounts. This creates a gap of up to nine times which a new product must cross in order for success in the marketplace.

*Concluding Thoughts:*

Prospect theory has proposed an interesting insight into the effect of how a decision is framed has an impact on the decision maker. Perception of a loss results in risk prone behavior, while perception of a gain results in risk adverse behavior. The results of their research suggest a modification to the traditional utility theory to incorporate these insights.

This section provides key aspects into the development of a model for measuring the potential value of a new innovation. They are:

- Evaluation of alternatives and objectives are dependent on how the issue is framed. This plays an important role in phrasing the objectives and goals for the survey. The goal of the model is to measure all objectives on the same scale. Therefore all objectives and goals need to be stated as if the consumer will receive a gain from the objective. The cost of a new product injects an issue. Cost is an important objective in evaluating new products. But customers view cost as a loss, where they see other objectives as a gain. Therefore phrasing is very important.
- Since organisms make comparisons based on their current assets, if a new product does not accomplish an objective of a previous product, it can have a large impact on the evaluation process.
- Losses are perceived as far more detrimental than gains.

## 2.5 Market Segmentation

Market segmentation has become an acquired art. The traditional rules of segmentation have been shown to be ineffective compared to new models and methodologies. Therefore, traditional segmentation methodologies are evolving. According to Yankelovich and Meer (2006), traditional demographics cannot serve as a basis for a marketing strategy. Rather traits such as values, tastes, and preferences have been shown to affect an individual's purchase intent.

These insights only strengthen the idea of identifying customer objectives which express customer needs and value structures. That being said, people in general have different needs and value structures. Yankelovich and Meer (2006) suggests the key to a successful segmentation is to group these individuals with similarities, and target groups which have needs that are unmet, unhappy, and likely to purchase the product.

A simple demonstration of a market segmentation is shown in Figure 9.

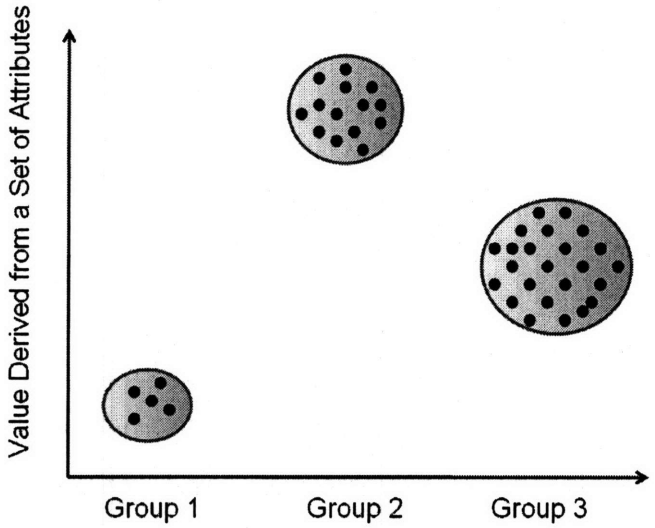



**Figure 9:** Basic depiction of a market segmentation

*Concluding Thoughts:*

A successful marketing strategy is dependent on the ability to identify a set of customers for the particular product. Along the way to identifying the customers, the strategy will start to delineate how their product will stand out from the competition by leveraging key traits, or objectives. Most companies target different market segmentation by brand positioning, or creating a brand that appeals to the average customer in the particular segmentation by leveraging the appealing objectives. Thus, each brand should identify a set of objectives which appeal to their target customers.

Some key ideas from this section to guide the formation of a model are:

- The model can be segregated to evaluate multiple market segmentations
- Customer data can help to formulate a brand strategy based on customer profiles. This strategy will help to assess how a new innovation is valued by each segmentation.

# 3 Solution Framework

The discussion thus far has shown significant evidence that a company developing a new product cannot operate in a vacuum. They must be intimately aware of the customer's needs at all times. This would include needs which are directly stated, as well as needs which the customer cannot express. It is up to the developing company to identify those needs to create solutions which deliver value.

In order to increase the odds of success, a company should develop a hierarchy of their customers' needs and where those needs fit in the classic Kano model. The hierarchy of needs should provide a scale to understand which needs are important, and by how much. The reality is these needs are based on internal manifestations which are unique to each customer. Therefore a scale must be able to translate multiple inputs from the value taxonomy identified by Aristotle on to a single scale for direct comparison and tradeoffs.

Traditionally, the approach for accomplishing this was to convert all needs into a monetary value for a comparison to the cost of acquiring the benefit. This process in itself injects a level of subjectivity due to the designers assigning a monetary value which is conjecture, at best. Additionally, since the designers are human by nature, Gourville (2006) has shown these monetary values will tend to be overstated up to three times their actual value.

## 3.1 A Scale for Measuring Value

An appropriate scale to measure value to the customer eliminates the subjectivity of the measurement and the bias of the designer. A common technique to solve the issue is to poll stakeholders directly with a survey. Pair-wise comparison questions allows the stakeholder to assess two different objectives and determine which need they prefer and by how much.

To place in context of an actual situation, an individual may be in the market to purchase a new product. This product is designed by the company to meet a specific set of objectives for the individual. Due to the competitive nature of the marketplace, there are multiple design alternatives and each may satisfy different objectives.

Therefore, an individual must make tradeoffs to select a product to satisfy their intended use. These tradeoffs represent an individual's opportunity costs: How much of an objective are they

willing to sacrifice in order to meet another objective? As previously mentioned, an individual will determine their opportunity cost based on internal representations, which are defined by their goals and value taxonomy.

Therefore, a survey must be able to assess a customer's preference of needs, and by how much. Pair-wise comparison questions have been shown to accomplish this goal. The question juxtapositions two objectives so a customer can make a direct comparison. An example is shown below.

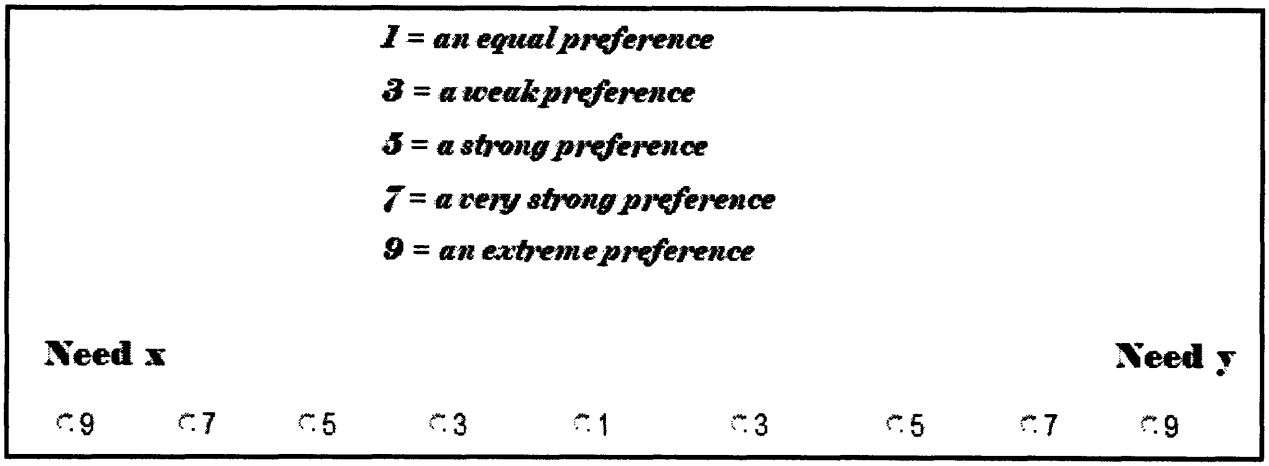



**Figure 10:** Example of a pair-wise comparison question to assess the value of a need

Creating a customer survey to answer questions in this particular format incorporates all of the value classes from the taxonomy, and projects onto a single axis eliminating the bias from the designer's perspective.

## 3.2 Translating Needs to Product Attributes

Customer needs can be stated in an objective format. For example, when purchasing a new computer, a person may state they wish to increase their current storage capacity. In this case, the product attribute would be the amount of memory in the hard drive. The computer landscape is an interesting exception. The products have created a language which some customers are stating their objectives and goals in the format of product attributes. For the storage capacity example, a customer might say, I want to increase my current hard drive to 500 gigabytes.

Not all products enjoy this luxury. Customers will state their objective and goals, and the designers are left to work out the translation to product attributes. Therefore, the value scale must be transparent in order to allow for translation into the language of the customer to the language of the designer. Non-transparency can lead to confusion, misconception, and an inaccurate model of the hierarchy of needs.

Since companies typically offer a variety of products to meet customer needs, using product attributes in the survey would create limitations to the model. Therefore, stakeholder's objective and goals, which are universally applicable, should be used to elicit feedback. It is up to the designer to translate these needs to product attributes.

The designer can use multiple techniques to translate customer objective and goals into product attributes. One method could be derived from the work done by Suh (2001) on axiomatic design. The methodology maps the functional requirements to design parameters. This is essentially the same process with different terminology. An adaption of his work is shown below.

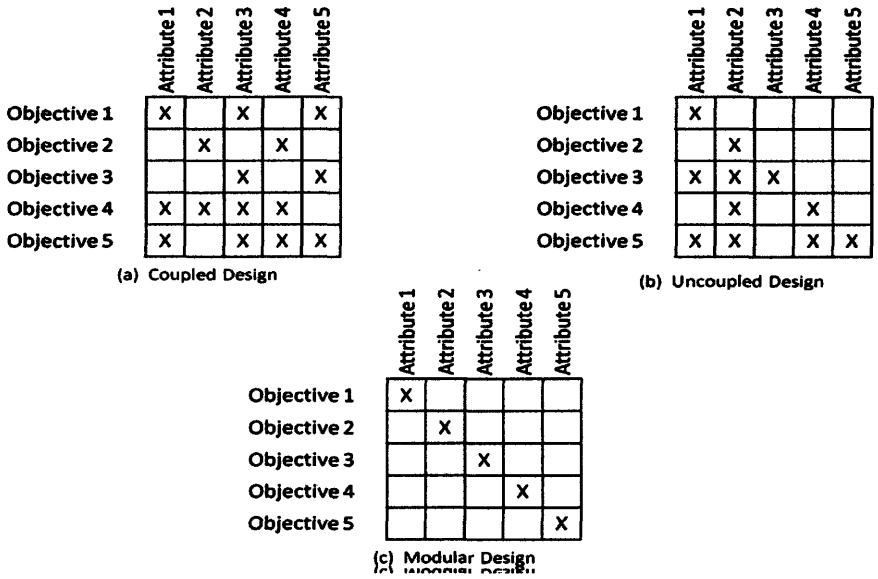



**Figure 11:** Axiomatic relationships

The relationships are a roadmap for product attributes which can be manipulated to deliver value. Following the process outlined shortly provides a designer with a powerful tool. If done correctly, it is possible to determine how the manipulation of a product attribute leads to a change in customer preference.

## 3.3 Introduction to Analytical Hierarchy Process

First described by Saaty (1980), Analytic Hierarchy Process (AHP) creates an organization of needs, reduction in complexity, and clarity in the vague area of customer objectives. The title of the methodology is an accurate description of the process. The customer needs are organized into a hierarchy in order to provide an analytical analysis of the results. The hierarchy aids in reducing complexity, by taking several customer objectives and reducing them into broad categories. Moving down the hierarchy, these individual needs will be broken out and separately addressed as shown in Figure 12. In the end clarity is provided by the structure of the hierarchy to present a clear category of needs, or areas where a company can deliver value.

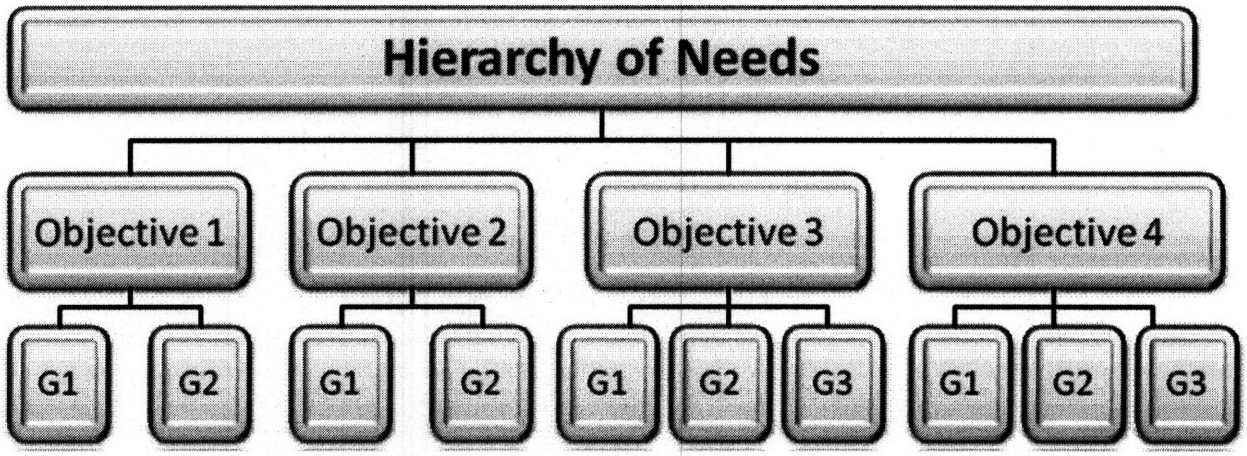



**Figure 12:** Depiction of a hierarchical system for value delivery

The tree structure determines what questions are needed in the customer survey in order to make a complete analytical assessment. The first level of the hierarchy lays out the top level objectives which are important to stakeholders. To meet the requirements from Keeney & Raiffa (1976), these are typically broad categories to minimize the total set. The top level objectives can be decomposed into sub-objectives, which add layers to the tree.

The final level is the statement of goals. Typically the goals outline increasing performance for a particular sub-objective which delivers value to the customer, such that when moving from goal one to goal two, there is an increase in the satisfaction or preference to the consumer. This provides an analytical evaluation of the return an individual receives by increasing their goals to the next criteria. An example is provided in Figure 13 to show the potential hierarchy of needs for an AHP assessment for a computer.

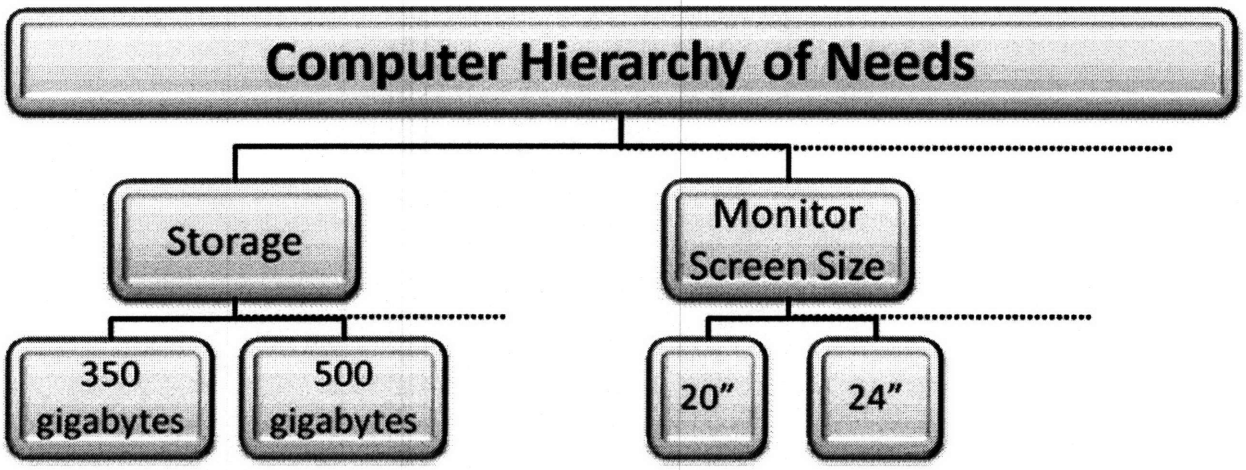



**Figure 13:** A section of a hierarchy of needs for a computer

The questions for a survey are populated from the AHP hierarchy structure. All pair-wise comparisons are made across a level, and within a branch of the tree. From the computer example, storage would be compared against monitor screen size and other objectives at that level. Likewise, a 20" monitor would be paired against a 24" monitor and other goals at that level, and contained in that branch of the tree. Therefore, the number of questions, Q, in a survey is dependent on the number of objectives (or goals), n, at each level. The number of questions per level can be determined by the equation:

$$Q = \sum_{1}^{n-1} n$$

The responses of the survey are used to populate a matrix to determine the principle vector. Each entry in the principle vector thus represents the how a consumer values the corresponding objective. A sample calculation is shown in appendix A.

The output of all the calculations is a numerical assignment for each node of the hierarchy tree, which represents the potential value to consumers. The tree structure provides a model to assess new innovations. Scoping the initial objectives on an innovation, the designer can rank where the product falls in the outlined goals for each objective. For example, during the initial scoping efforts, the new product is targeted to meet goal 2 but not goal 3 of objective 4 from Figure 12. Therefore, the product will be assigned the value of goal 2 for that particular objective.

The final metric for potential customer value is determined by rolling up the tree. A sample is provided in appendix B. Starting from the bottom and working up, multiply each goal by the

corresponding node at the next level. Then sum all the branches at that level which are contained by the next highest node. By continuing this process all the way up the tree, the output will be a numerical representation of the potential value of a new product.

Finally, the tree structure provides a modular interface to continually update with additional sub-objectives with minimal effort. As long as the sub-objective does not change the hierarchy, they can be added and assessed easily.

## 3.4 The Consistency of Survey Responses

Pair-wise comparisons present the opportunity for respondents to unintentionally give inconsistent responses to a set of questions. Thus, a benefit of AHP is the opportunity to assess the consistency of a respondent's answers. Devised by Saaty (1980), the consistency ratio is a measure of deviation from consistent responses, normalized by a random deviation dependent on the number of objectives (or goals) measured.

For example of consistent responses, a company may want to measure three objectives, A, B, and C. The following is a sample of the individual's responses.

*A is preferred 2 times more than B*
*B is preferred 2 times more than C*

Thus, in theory, A should be four times more preferred than C to be perfectly consistent. The consistency ratio is a measure of deviation from this theoretical response. If the individual's responses are perfectly consistent, the consistency ratio will be zero. The further the deviation from consistency, the larger the consistency ratio.

The consistency ratio, CR, is a function of the maximum eigenvalue, $\lambda_{max}$, and the number of objectives (or goals) in the matrix, N. A more formal definition is:

$$CR = \frac{CI}{RI}$$

Where RI is the random index, which is a function of N. The random index is a factor used to represent the random error associated with a matrix of size NxN. CI is the random index and is defined as:

$$CI = \frac{\lambda_{max} - N}{N - 1}$$

Through his studies, Saaty, who pioneered the consistency ratio, suggests the deviation of the CI from the RI as less than 10% as a limit for consistent responses. In this thesis, we use the CR threshold of 0.1 as a criteria for consistency in the survey responses as shown in the next chapter.

## 3.5 Pair-Wise Comparison Scale and the Effect on the Consistency Ratio

The consistency ratio is a valuable tool for determining the consistency of responses for objectives and validity of the model. As the assessment moves down the tree to goals evaluation, the consistency ratio sometimes breaks down due to the scale of the pair-wise comparison. This limitation provides arguments to use the consistency ratio for another purpose at the bottom level of the hierarchy. Rather than determining the consistency of responses, the consistency ratio can be used to verify a need classification according to the Kano model.

First an elaboration on the limitations of the scale. The consistency ratio breaks down due to the measurement scale presented in the survey. Recalling from the previous section, the scale was a one to nine scale with five possible choices. Again for practical purposes, say a designer wishes to measure the value of increasing the size of a hard drive with choices of 300 gigabytes, 500 gigabytes, and 1 terabyte. Also assume for the sake of discussion that storage capacity is classified as a delighter need in the Kano model, meaning a slight increase in performance results in a large increase in customer satisfaction. When the survey is presented to the individual, the designer may see responses such as this:

*500 gigabytes is 9 times more preferred than 300 gigabytes*
*1 terabyte is 9 times more preferred than 500 gigabytes*

In order for the consistency ratio to be zero, the individual would have to respond that 1 terabyte is 81 (9x9) times more preferred than 300 gigabytes. This statement may be true, but this is not an option for an individual to select. The most they can select is nine times more preferred, therefore increasing the CR above the acceptable threshold.

This breakdown could also occur for satisfier needs if the levels of performance are set to far apart, but it less likely to occur. So for measuring the value of a goal, the practical interpretation

of the designer plays a part. In the mind of the designer, they must make practical judgments on the interpretation of data they receive. They must determine, are the survey responses inconsistent, or could the need be classified as a delighter need in the Kano analysis.

## 3.6 Combining Responses from Multiple Individuals

The discussion thus far has revolved around the idea of eliciting one individual's response to a survey. In reality, a new product must be robust to multiple individuals which entail the combination of multiple inputs. This could be a rather arduous task, but if done properly it can create a lot of value for the designer. If done accordingly, the designer can assess the product's ability to compete in the marketplace, the relative risk associated with the product, and the product's robustness to multiple market segmentations.

In order for a product to compete in the marketplace, it has to compete on two similar tracks. The product has to be better than the customer's current asset to compel them to switch to the new product, as well as deliver value which exceeds competing products. By conducting a market survey as outlined above, a designer can make these comparisons of value delivery based on objective data received from actual customers.

The comparisons need to be performed from the perspective of the customer. As previously mentioned, value to a customer is dependent on their psychological perspective. Therefore, when making a comparison between a new product and a customer's existing product, the model must incorporate the fact that customers over-value their current assets, as identified by Gourville (2006). When making a comparison between existing products, there is a level playing field in which customer value each product on the same scale and avoid the bias.

The comparisons made on multiple scales suggest a level of risk based on the unique perspective of each individual. With each questions, there is a distribution associated with the number of responses. For pair-wise comparisons, answers tend to be polarized towards one end of the scale, but there is a spread of answers over the scale which represents the unique preference structure of multiple individuals. By propagating this distribution of answers through the calculations for the hierarchy tree, a level of risk for a new product can be determined by the standard deviation of each entry in the principle vector.

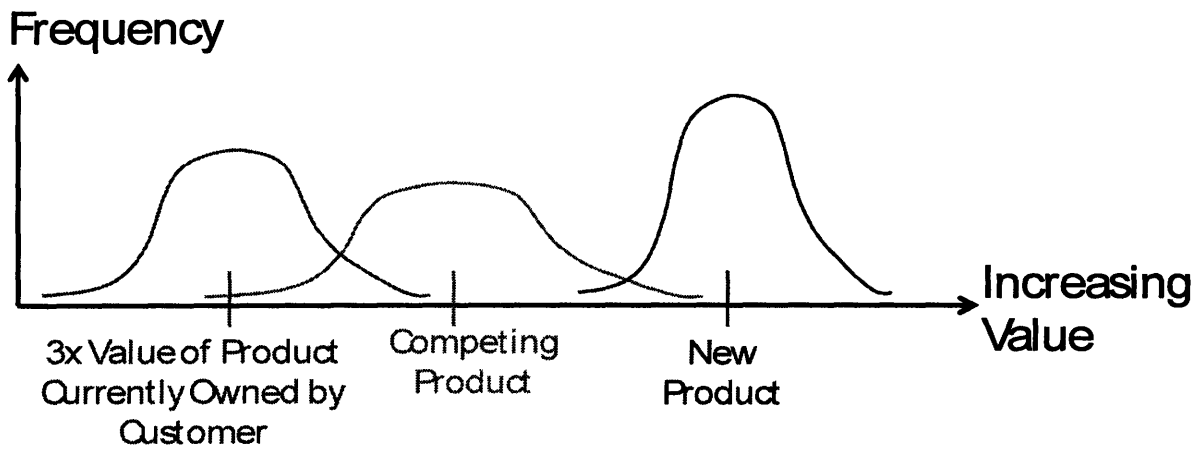



**Figure 14:** An example of a risk assessment for a new product.

The level of risk is determined by the overlap of distributions shown in Figure 14. Figure 14 presents an ideal case where a new product value exceeds the competition. With some overlap, as shown by the new product's value distribution overlap with the competing product's value distribution, the designer must base their decision on the probability of overlap, or the level of risk involved with the product not providing any incremental value.

This strategy holds a lot of merit, but what happens when the customer base is highly fragmented with multiple segmentations. Without taking into consideration the segmentations, a large opportunity could be lost to deliver a product with an increased value to a slightly smaller population. What is good for one segment of the market may not be optimal for all.

Companies lay out brand strategies to identify potential customers for its products based on a set of objectives which are critical to that market segmentation. The survey can support and foster these strategies. The results can help to build the context of how to properly position a product in the marketplace. Customer data can be extracted from the survey to show the value structure to multiple segmentations. Thus a new product can be measured based on responses of the entire population, as well as specific market segmentations. A company with multiple brands would benefit by aligning new products with the appropriate brand strategy.

## 3.7 Research Methodology

Before diving into the case, a brief synopsus will be provided to show the necessary steps in order to generate a model. The purpose of this section is to outline the steps in case anyone wants to replicate the results, or create a similar model for other business ecosystems.

### 3.7.1 Getting to Know the Customer

The foundation of the model is to know the customer and their objectives. A model will prove worthless if the customer objectives are improperly assessed. Several techniques can be used such as focus groups, surveys, interviews, or observing individuals operate their current products.

The output of these activites should be a set of objectives which meet the criteria laid out by Keeney & Raiffa (1976). The objectives should be complete while minimizing the total set. They must be operational, non-redundant, and decomposible as well. Saaty (1980) identifies two additional requirements of the objective set. They must be preferentially independent and utility independent. This is to say the preference and utility of an objective is not dependent on a different objective.

These objectives can be turned into a customer survey. One of the challenges in creating the model is defining the objective in a concise manner to eliminate ambiguity. The questions must be phrased such that the customer intake, identify, and operationalize the actual objective. Therefore, before a survey can be created, the objectives must be constructed in the language of the consumer. This may take several iterations, but interaction with actual customers is invaluable.

### 3.7.2 The Survey

The survey itself is a lot like phrasing the objectives. The instructions have to be unambiguous to eliminate uncertainty to the individual giving their responses.

During the case study, several objectives were present in the marketplace, which resulted in a large horizontal hierarchy. In order to complete the tree, the final survey consisted on 189 questions. For pair-wise comparisons, the most an individual can perfrom is around 30 questions before fatigue starts to effect answers.

Therefore, the survey was broken down to six individual surveys. Questions were randomly selected and placed in an appropriate survey. Therefore, when taking a survey, an individual would only be presented with one sixth of the questions. This was an attempt to reduce the time for individuals to fill out their responses and ensure accurate data.

The survey was then administered to multiple individuals. For this case study, an online survey was conducted to reach as many consumers as possible which spans multiple geographical locations. We obtained 491 responses from different populations as shown in the next chapter. Data was collected over a two week time period.

### 3.7.3 Data Calculation and Results

Appendix A provides detailed calculations to determine the principle vector and consistency ratio for a matrix. This process was repeated several times in order to calculate the principle vectors for each node of the hierarchy.

The data was further reduced and fractionated according the market segmentation identified by a company's brand management. The data was filtered to identify potential individuals who would fit the brand profile. Their results were then used to determine the value of a new product to each market segmentation.

The output was a model to assess a new product's potential value to customers. The value was assessed for the entire population, as well as for individual brand segmentations. Results and discussions are presented in the next chapter.

## 3.8 Summary

The amount of effort to create a model to measure potential value of a new product is by no means an easy task. Yet the benefits from the expended effort are tremendous.

- Capability to assess the potential value delivery of a new product based on the initial scoping efforts.

- The ability to push the evaluation of potential value delivery further up in the design process creates opportunities to avoid potential costly investments, modify system goals before work begins, or re-evaluate a potential technology

- Determine a product's robustness to market segmentations. In particular, there is an opportunity to identify a brand strategy based on a new product or technology.

- Assess the potential risk of a new product.
- Modular architecture of the hierarchy tree. This aides in the effort to update a hierarchy as new data and objectives emerge over time.

# 4 Application

The advantage of this framework is the flexibility to apply the methodology across multiple markets. For the purpose of this discussion, the framework was applied through a division of a company which produces consumer goods. The company has three brands which hold a lot of value in the marketplace. Products are designed for the different brands which are market leaders in their segments. Therefore, new innovations must align with the customer segmentation in order to deliver value. New innovations for this particular market segmentation are historically incremental innovations, or changes to the existing architecture. These changes are designed to deliver value to consumers while not changing the existing customer preferences. Further information about this company and its products are excluded from this thesis due to industrial protection agreements.

The intent of this application is to build a foundation for building upon in the future. By establishing a foundation, the hierarchy can be improved and refined over time as customer needs and value structures change.

This section will cover the application of the described framework to this particular marketplace. It will outline the creation of the hierarchy of needs and value tree. The results and data analysis from the survey to measure each objective in the hierarchy will be presented next. Finally, this data will be used to measure the potential value of two new innovations the company is developing.

## 4.1 Creating the Hierarchy

In order to create the hierarchy of needs, detailed knowledge is needed of the customer and what they look for in the products. The conglomerate of needs can be subdivided into subgroups, and then broken down further. This data was collected both quantitatively and qualitatively.

The quantitative objectives were determined from the company's consumer research performed over the past two and a half years. The consumer research was mined for important information on what the company was trying to establish and the recorded responses of the consumer. Another methodology was to interview brand managers to elicit responses which they felt were important to their brand image. The outcome was a list of consumer objectives, which resulted in positive feedback during the consumer research.

The qualitative methodology was an attempt to express objectives which may have been overlooked, not tested in the research, or the customer was unable articulate. Consumers were observed interacting with the products, shoppers were interviewed after they purchased a new product, and users were interviewed to see what they liked about their current products. The result was a list similar to the quantitative method, except these objectives were more forward looking in time and ambiguous.

With the list of objectives, the wording of each objective was modified and tested with users to eliminate some of the ambiguity and ensure they were the actual needs being expressed. Once the wording was finalized, the objectives were divided into subgroups. The first level of subgroup had to be broad to cover several sub-objectives. This aides in building the foundation as mentioned previously. At a later point in time, the heirarchy can be revisited and modified by adding sub-objectives. The top level objectives were broad, but concrete so a user would operationalize what is included in the sub-group.

In the end, there were 16 top level objectives. Each of the objectives were mutually independent of each other, while still trying to maintain a minimal set. Breaking down the top level objectives resulted in several sub-objectives. For the purposes of this discussion, only a select few of those sub-objectives were included. These select few sub-objectives resonated well with consumers and were considered to be of the highest value. Future studies would be needed to fill in the additional sub-objectives.

The final sub-objectives were arranged according to the top level objectives. An example of a sub-objective would be "The new car increases the miles per gallon of gas". Moving down to the next level, each sub-objective was assigned a goal to test how consumer value increasing performance. Using the miles per gallon example, goals would be assigned by 20 miles per gallon, 30 miles per gallon, and 40 miles per gallon. This aides designers to show by increasing the performance, they increase the potential value to consumer by a certain amount.

The end result was a large hierarchy which can be used as a foundation to build on in the future. The first level of the hierarchy includes the top level objectives (A1 – A16), second level were the sub-objectives (A1-1 through A16-1), followed by the third level of goals for the sub-objectives as shown in Figure 15.

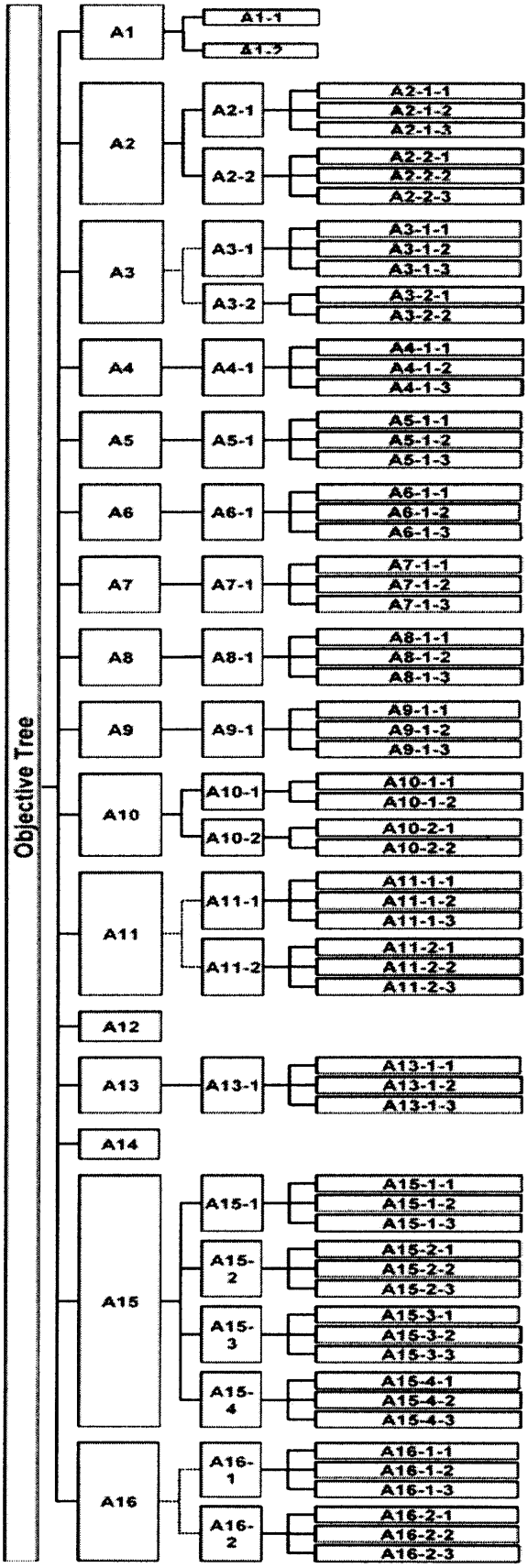



**Figure 15:** Hierarchy tree for a particular market

This tree provides a guideline for creating the customer survey with the appropriate questions. Comparison questions are asked within a branch and within a level. Therefore, level two sub-objectives are not directly compared to top level objectives. This aides in the final calculations of the potential value of a new product.

## 4.2 Survey Results

Working down the tree, 189 questions are needed in order to populate the appriopriate branches of the tree. To reduce the strain on individuals, the large question set required the overall survey to be divided into six smaller surveys of approximately thirty questions each. Questions were randomly assigned to each survey such that one person would answer random questions from all areas of the hierarchy. Therefore, one person would not take the entire survey.

The issue of concern would be the consistency of answers within a survey, and between a survey. This places a large emphasis on the consistency ratio for the top level objectives. In an effort to determine the consistency of responses across all surveys, the consistency ratio would have to be minimal, or less than 0.1 in order to ensure consistent responses.

Ideally the survey will be issued to people who interact with the product frequently, and play a large role in the decision making process. Due to the nature of the product, the demographics of responses need to be more female than male, and roughly an age bracket between 20 to 60 years of age, with a majority falling in the middle of that age span. As it will be shown shortly, the responses met these criteria.

The survey was issued to 491 consumers over the internet. The consumers provided their demographics before being routed to the individual surveys based on their birthdate. The demographics collected are shown in Tables 2 through 5.

**Table 2:** Gender information of the survey respondents

| Response | Frequency | Count |
|---|---|---|
| Male | 38.9% | 191 |
| Female | 61.1% | 300 |
| **Valid Responses** | | **491** |
| **Total Responses** | | **491** |

**Table 3:** Age of survey respondents

| Response | Frequency | Count |
|---|---|---|
| Less than 20 | 0.2% | 1 |
| 20 to 29 | 20.4% | 100 |
| 30 to 39 | 21.0% | 103 |
| 40 to 49 | 30.1% | 148 |
| 50 to 59 | 23.8% | 117 |
| 60 to 69 | 4.3% | 21 |
| Greater than 69 | 0.2% | 1 |
| **Total Responses** | | **491** |

**Table 4:** Responsibility of the product operation of survey respondents

| Response | Frequency | Count |
|---|---|---|
| I am the primary operator of the product | 56.0% | 275 |
| I share the operation with someone | 28.9% | 142 |
| I assist in the operation only when needed | 9.6% | 47 |
| Someone else is the primary operator | 5.5% | 27 |
| **Total Responses** | | **491** |

**Table 5:** Number of respondents for each survey

| Response | Frequency | Count |
|---|---|---|
| Survey 1 | 16.5% | 81 |
| Survey 2 | 17.3% | 85 |
| Survey 3 | 17.3% | 85 |
| Survey 4 | 15.7% | 77 |
| Survey 5 | 15.1% | 74 |
| Survey 6 | 18.1% | 89 |
| **Total Responses** | | **491** |

## 4.3 Data Analysis

For each question, it is important to understand two values: the average response and the distribution of responses. The average response is straight forward and results in a deterministic model for the hierarchy. The deviation of responses can be assessed with a probalistic model to measure the level of risk associated with each response.

For each question, an appropriate distribution was determined and assigned according to the recorded responses. A typical question tended to be skewed towards one end of the measuring scale, with a bulk of the answers towards the other end. As a result, a beta distribution was used in most cases as it provided the best fit to the data. An example is show in Figure 16, where actual represents the recorded responses from the survey, and the distribution is the probalistic assessment based on the actual data.

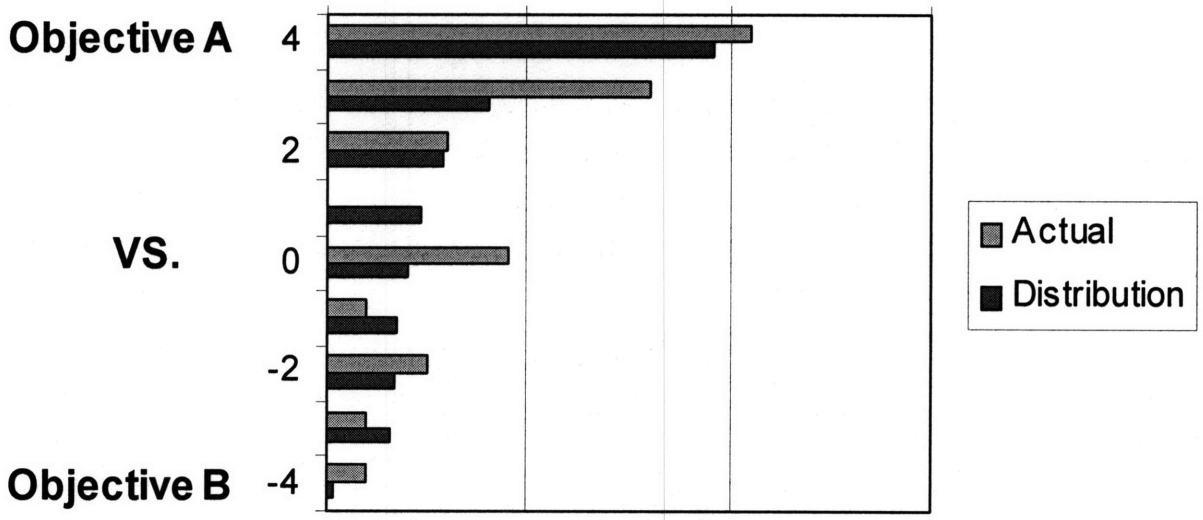



**Figure 16:** A beta distribution fit to data from a question on the survey.

Following the calculations outlined in appendix A, the principle vectors for each branch and levels of the hierarchy can be determined. The potential value of each top level objective is shown below.

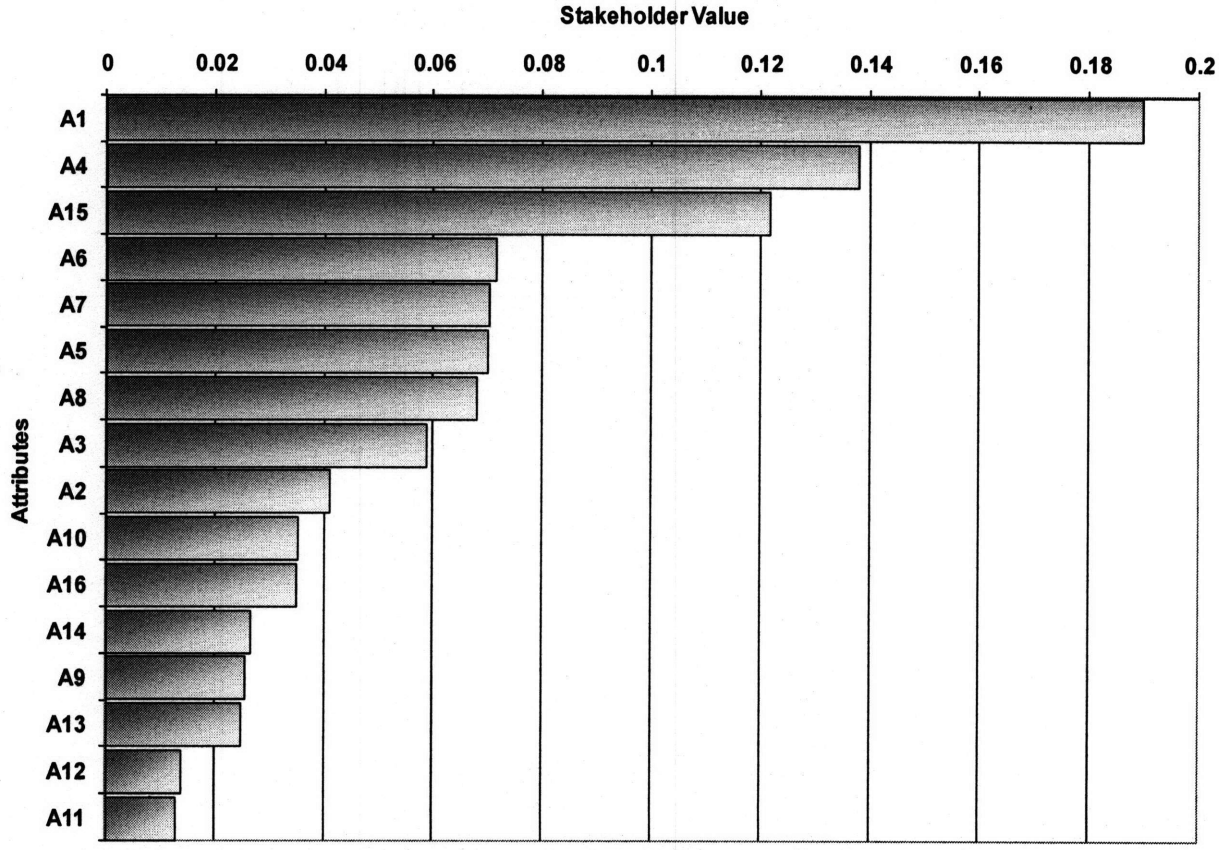



**Figure 17:** Pareto diagram of the quantitative value metric for the top level objectives

The question thus becomes how consistent were the responses. The deterministic model, which was used to calculate the quantitative value, resulted in a consistency ratio of 0.067559. From Saaty's work, these results can be considered consistent with the responses given in the surveys since the consistency ratio is less than 0.1. This confirms that there is a hierarchy of needs for this particular market, and this is how the group of individuals value each high level objective.

All data points are provided in appendix C. Results of the survey are shown in Figure 17 which demonstrate that A1, A4, and A15 are the objectives that were perceived to be most valuable by the survey respondents.

## 4.3.1 Consistency Ratio for Sub-Objectives

From the value hierarchy presented, some of the sub-objectives have consistency ratio (CR) values which exceeds the the threshold suggested by Saaty. Upon further investigation, there was a trend which was consistent across a lot of the answers which would explain the unusually high results. This trend was discussed in section 3.5, where the pair-wise comparison scale effects the consistency ratio. For each question, an increase in performance for an objective results in a large increase in customer satisfaction or value. A sample is shown in Figure 18.

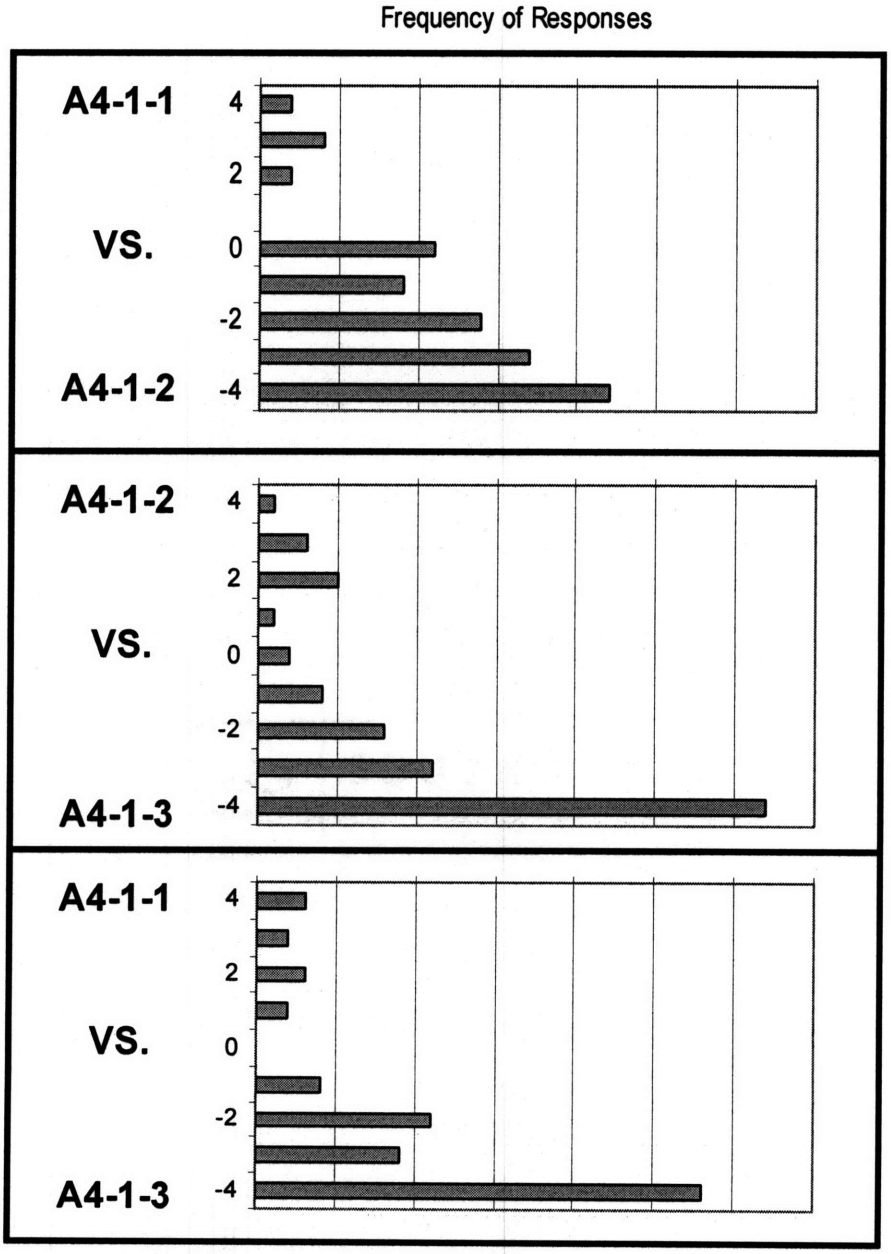



**Figure 18:** The effect of the measurement scale on the consistency ratio

According the these charts, sub-objective A4-1-2, is roughly five to seven times more preferred than A4-1-1. The second chart shows A4-1-3 is roughly seven times more preferred than A4-1-2. For consistency, A4-1-3 would have to be thirty-five (5x7) to forty-nine time (7x7) more preferred than A4-1-1. This is not possible due to the limitations of the scale because at the most extreme it can only indicate that these sub-objectives are nine times more preferred.

This is obviously a limitation to the methodology, but it provides a lot of insight into how an individual perceives these objectives. The Kano model for needs classification provides some interesting foresight into how to interpret these findings. According to the Kano model, there are needs which provide a large increase in customer satisfaction from a small increase in the performance of the system, referred to as delighters.

Therefore, for the lower sub-objectives, the consistency ratio can be used as a metric for the qualification of a need in the Kano analysis. Re-visiting the high level objectives, Figure 19 indicates the regions of the hierarchy which created a high, mid, and low consistency ratio. Some data were not available due to not testing the goals for that particular sub-objective.

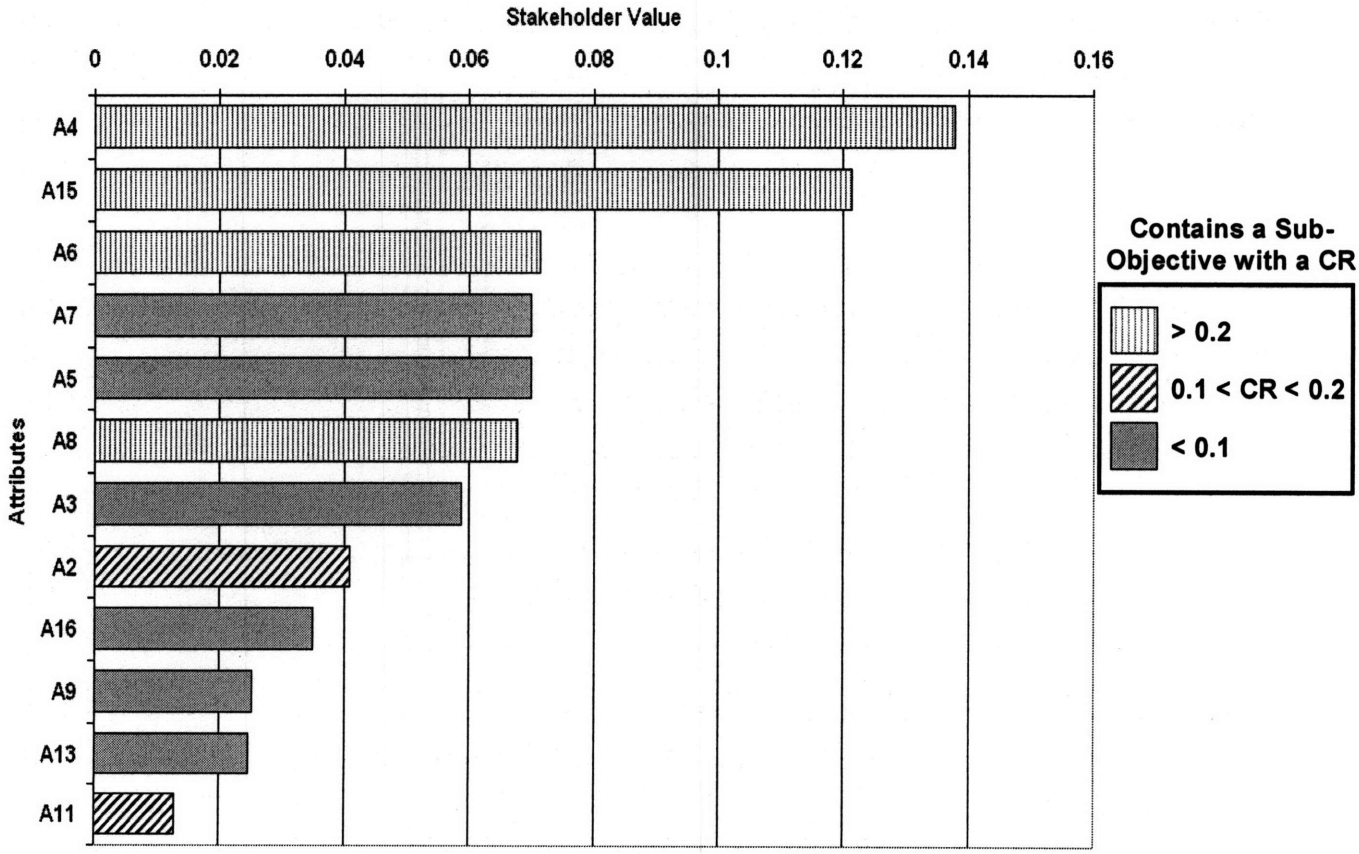



**Figure 19:** Classification of top level objectives dependent on if they contain a sub-objective with a high consistency ratio

Breaking down the data to sub-objectives, they rank as follows:

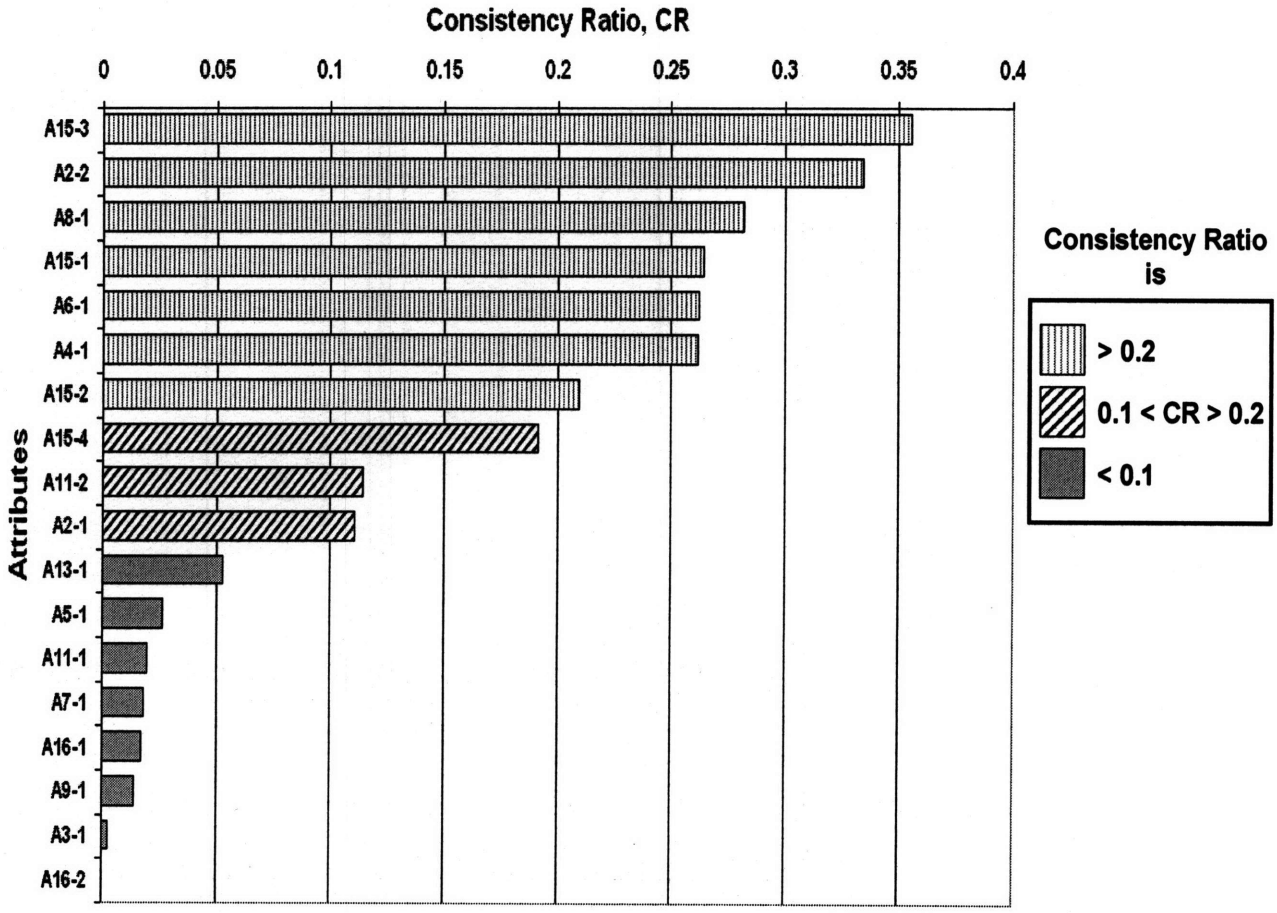



**Figure 20:** Ranking of the consistency ratio for each sub-objective

Utilizing this methodology requires attention to detail. The goal matrix for each sub-objective must be examined individually to make a distinction between a delighter need, or the responses from individuals were inconsistent. Proper utilization results in a classification of each sub-objective into the Kano model as shown in Table 6. There were two criteria in order to determine the sub-objective classification. The first was the shape of the data compared to the Kano diagram shown in Figure 5. For example, if value increased exponentially with an increase in performance, this would suggest a delighter need. The second criteria was a high consistency ratio as outlined above. Higher consistency ratios were classified as a deligher, as long as the data justified this classification. Lower consistency ratios were classified as a satisfier or must have.

**Table 6:** Classification of sub-objectives into the Kano Model

| Must Haves | Satisfiers | Delighters |
|---|---|---|
| A1-1 | A5-1 | A2-2 |
| A1-2 | A7-1 | A4-1 |
| A2-1 | A9-1 | A6-1 |
| A3-1 | A11-2 | A8-1 |
| A11-1 | A13-1 | A15-1 |
| | A15-4 | A15-2 |
| | | A15-3 |

### 4.3.2 Probabalistic Assessment

It can be noted from previous figures the level of uncertainty in answers due to the deviation of responses. The deterministic model provides a lot of valuable information, but it should not be analyzed in isolation. The deviation of responses is just as important.

Using the software Crystal Ball, or a similar software package, the effect of the deviation of answers can be studied. This will help to identify trends which are not apparent in the deterministic assessment.

The top level objectives results tended to be normally distributed as shown in Figure 21.

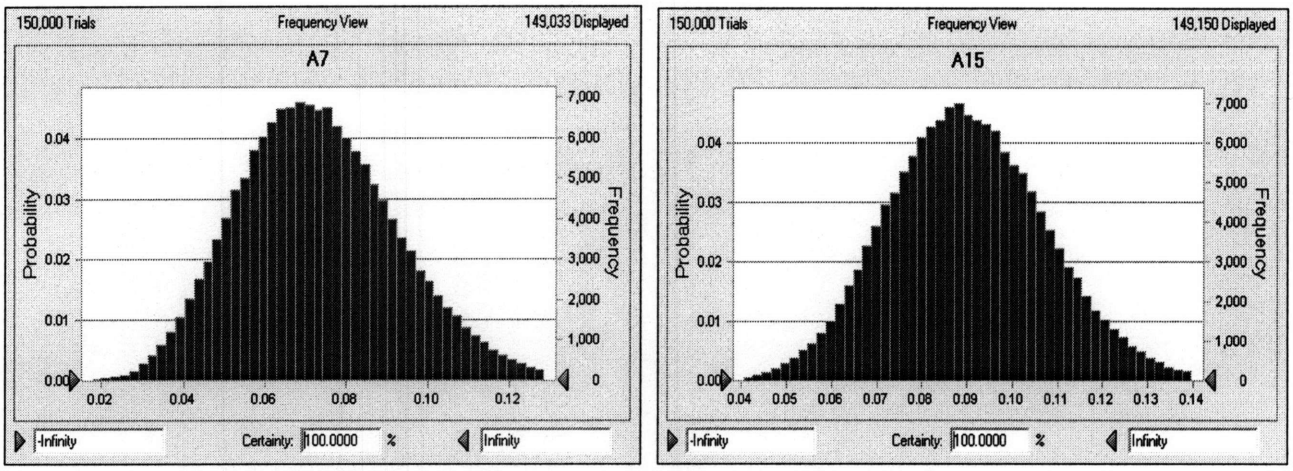



**Figure 21:** Probabilistic assessment of top level objectives

The deviations started to play a real role when moving down the sub-objectives. The results were bi-modal distributions as shown in Figure 22. The cause of such a distribution is how the sub-attributes appeal to different market segmentations. This provides supporting evidence that the market is fractionated. For example, in Figure 22, A10-1 was directly compared to A10-2. The marketplace was split on which they value the most, represented by the bi-modal shape of the graphs. Meaning half of the market valued A10-1 signifcantly more than A10-2, while the other half of the market valued A10-2 significantly more than A10-1.

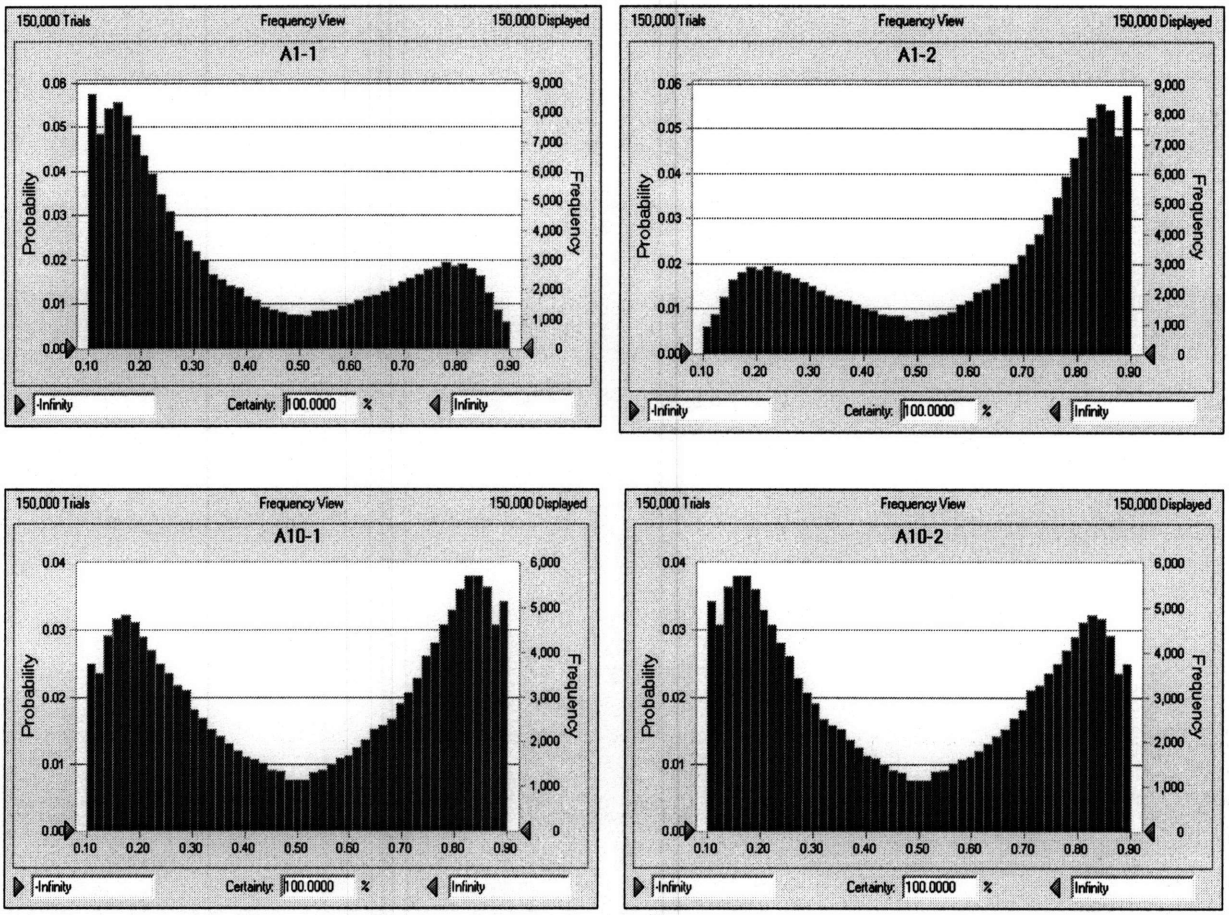



**Figure 22:** Probabilistic assessment of sub-objectives A1-1 and A1-2, as well as A10-1 and A10-2, which shows the fractionated marketplace

Thus, the probabalistic model serves two purposes. First, it demonstrates a high level of fractionated responses to suggest the current marketplace has several market segments. This finding will be incorporated into the final model in order to expand its capabilities. Secondly, it provides a probabalistic model for assessing the potential value of a new product innovation.

### 4.3.3 Filtering Responses for Different Market Segmentations

Since the current marketplace is segmented, the model can provide greater discrimination by filtering the survey responses to identify customers of each segmentation. The company being studied releases products under three brand names. They have benefited from years of experience when interacting with their customers, such that they have positioned each brand to appeal to the different market segmentations.

Their experience has lead to a profile of the customers in their market segments. Leveraging their information, it is possible to identify which sub-objectives appeal to each brand segmentation. The results of this work is a list of five to six sub-objectives that can be used to identify customers who fit each brand segmentation based on the survey responses.

The algorithm to identify customers is quite simple. For one brand, there is a list of five sub-objectives which appeal to their customer profile. Questions from the survey which tests these sub-objectives can be evaluated to see how each individual value those properties. Responses which preferred the brand objective received a positive score correlated to their response. Responses which preferred another sub-objective over a brand sub-objective received a negative score correlated to their response. In the end, each individuals scores were summed, and scores in the top 25% were identified as potential respondents who fit that brand profile.

Once the customers are identified, all of their responses are extracted, and analyzed independently of the botton 75%. The steps are repeated for each of the three brands to determine the principle vectors for each matrix of the hierarchy, as well as the consistency ratios. The result is four independent models: how the general public values multiple objectives, as well as how customers from each of the three brand profiles value multiple objectives as shown in Figure 23.

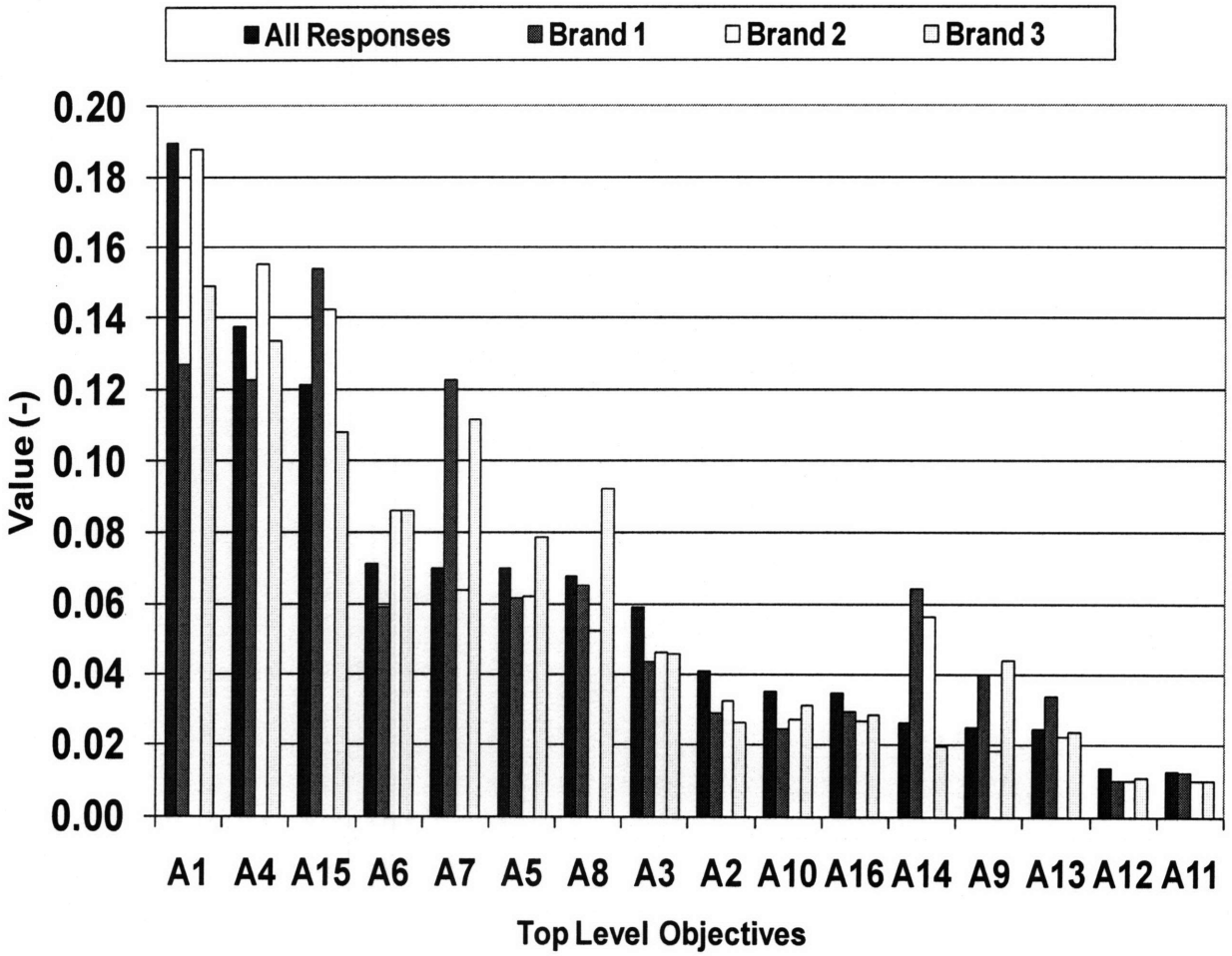



**Figure 23:** The value of each top level objective for each brand profile

Each profile is seperated and provided for further analysis.

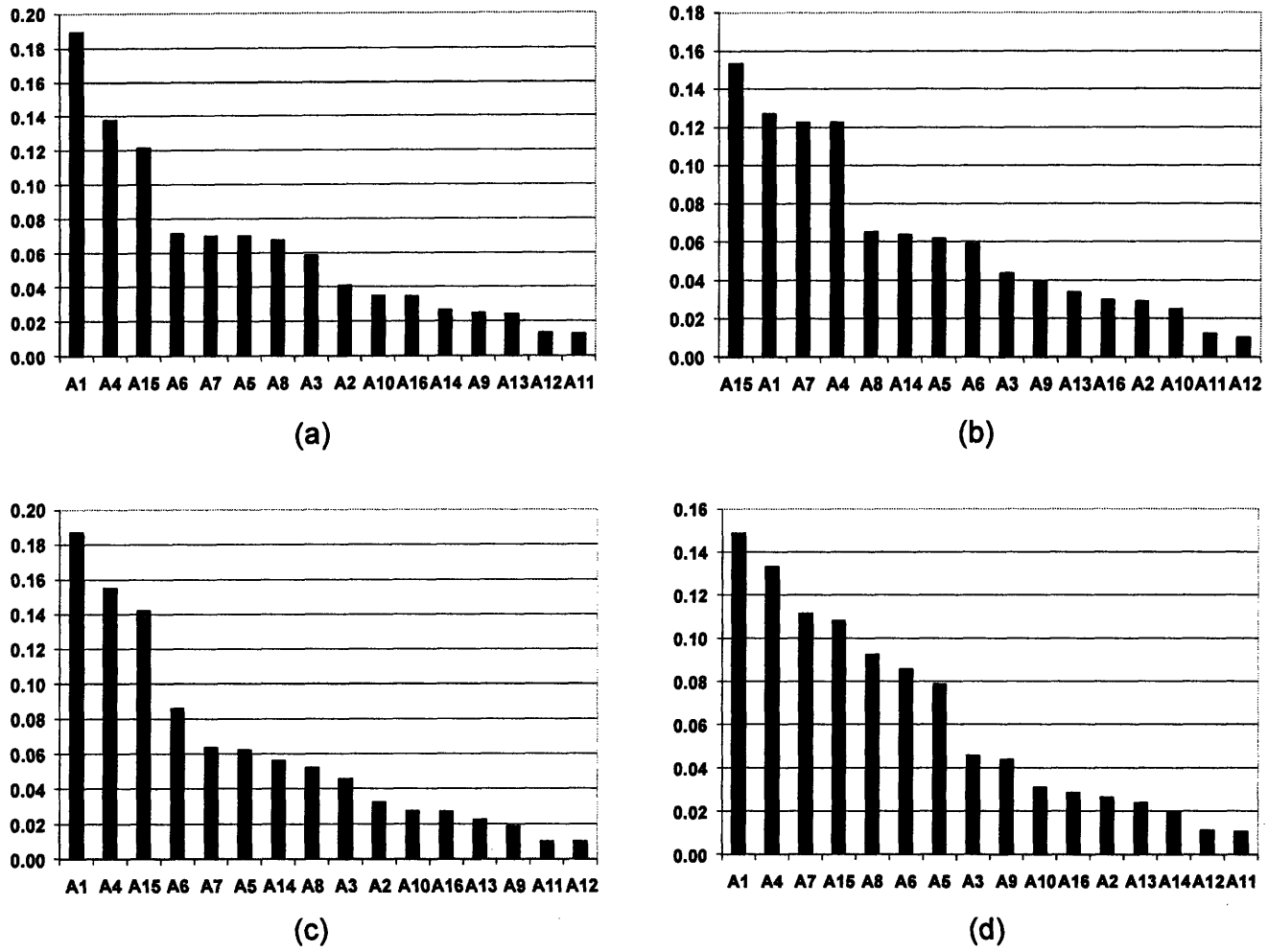



**Figure 24:** Value structures for the top level objectives based on profiles of: (a) all respondents, (b) Brand 1 customer profiles, (c) Brand 2 customer profiles, (d) Brand 3 customer profiles

This provides insights on two major fronts for the company to capitalize. The first is obviously the structutre of how customers in their brand segmentation rank the top level objectives, as well as sub-objective and goals. This provides an assessment of not only the attributes which were identified by the brands, but systematically incorporates the rest of the objectives to provide a complete picture of the value structure.

Secondly, it provides an avenue to ensure new product innovation aligns with a brand strategy. New product innovations can be technically sophisticated and reliable, but still fail to deliver value to the consumer. Even more damaging, is delivering a product which does not appeal to a company's customer base. Conflicting messages are detrimental to a company's effort to deliver value.

The model provides guidance to how new innovations will be valued by users of all segments. The company can now make appropriate considerations when deciding the branding of a new product launch. The new product can be evaluated for each brand to aide in developing an appropriate strategy to align a technology to a brand.

Charts to show the value of sub-objective and goals are shown in appendix C.

## 4.4 Product 1 Value Assessment

New products can now be evaluated early on in the design process before a lot of the capital costs are invested. The outcome of the evaluation will be a numeric dimensionless number which represents the estimated value of the new product to consumers. This number in isolation is non-informative, suggesting a need for a relative comparison. It is up to the user of the model to select the best alternative to the new product in question. In most cases, this could be the product it is replacing.

The first product is an incremental improvement to the existing architecture to increase the performance of a few sub-objectives in order to simplify the operation of the product. Although, to benefit from the simplification in operation, the traditional operation of the product must change, which could have a negative impact in the product's potential value.

The new product is in its early phase of development, but the goals of the system have been laid out in a Quality Function Deployment (QFD) diagram. These system goals were compared to the goals outlined in the sub-objectives. One system goal was still undetermined, A16-1, but a range was specified. The uncertainty of this goal arises from technological complexity. Therefore, the new innovation will be assessed at the low end, A16-1-2, and high end, A16-1-3, of the specified range. The low end will be called option A and the high end will be called option B.

Since the new product is an addition to the existing architecture, the alternative product for comparison would be the product without the updated feature, this is referred to as option C. It should also be noted the customer's existing product is equal to the products in the current marketplace, therefore they will both be assessed under option C.

**Table 7:** Value assessment of the scope for option C on product 1

| Sub-Objective | Alternative Product Sub-Objective Goal | Score for Entire Population | Brand 1 Score | Brand 2 Score | Brand 3 Score |
|---|---|---|---|---|---|
| **A2-1** | A2-1-2 | 0.40 | 0.34 | 0.61 | 0.57 |
| **A2-2** | A2-2-2 | 0.25 | 0.27 | 0.26 | 0.24 |
| **A3-1** | A3-1-2 | 0.46 | 0.47 | 0.46 | 0.41 |
| **A3-2** | A3-2-1 | 0.17 | 0.17 | 0.16 | 0.16 |
| **A4-1** | A4-1-1 | 0.08 | 0.08 | 0.08 | 0.07 |
| **A5-1** | A5-1-1 | 0.07 | 0.06 | 0.07 | 0.08 |
| **A6-1** | A6-1-2 | 0.26 | 0.26 | 0.26 | 0.27 |
| **A7-1** | A7-1-2 | 0.42 | 0.33 | 0.38 | 0.36 |
| **A8-1** | A8-1-2 | 0.25 | 0.25 | 0.24 | 0.24 |
| **A9-1** | A9-1-1 | 0.11 | 0.10 | 0.09 | 0.10 |
| **A10-1** | A10-1-1 | 0.18 | 0.21 | 0.23 | 0.16 |
| **A10-2** | A10-2-1 | 0.23 | 0.23 | 0.19 | 0.23 |
| **A11-1** | A11-1-1 | 0.25 | 0.22 | 0.22 | 0.29 |
| **A11-2** | A11-2-1 | 0.31 | 0.27 | 0.30 | 0.29 |
| **A13-1** | A13-1-1 | 0.16 | 0.11 | 0.16 | 0.27 |
| **A15-1** | A15-1-2 | 0.21 | 0.20 | 0.19 | 0.20 |
| **A15-2** | A15-2-2 | 0.20 | 0.19 | 0.19 | 0.21 |
| **A15-3** | A15-3-2 | 0.23 | 0.23 | 0.24 | 0.22 |
| **A15-4** | A15-4-2 | 0.27 | 0.24 | 0.23 | 0.24 |
| **A16-1** | A16-1-1 | 0.45 | 0.45 | 0.55 | 0.57 |
| | | | | | |
| **Totals*** | | **0.4272** | **0.3910** | **0.4354** | **0.3824** |

* See appendix B for explanation of this calculation.

Brand 2 has the highest absolute value for option C on product 1. Therefore, this brand segmentation currently values the alternative to the new product more than other segmentations. This may indicate that Brand 2 will also value the new innovation the most as well. A detailed assessment is shown in Table 8.

**Table 8:** Value assessment of the scoping for option A and B on product 1

| Sub-Objective | Product 1 Scope for Sub-Objective Goals | Score for Entire Population | Brand 1 Score | Brand 2 Score | Brand 3 Score |
|---|---|---|---|---|---|
| **A2-1** | A2-1-2 | 0.40 | 0.34 | 0.61 | 0.57 |
| **A2-2** | A2-2-2 | 0.25 | 0.27 | 0.26 | 0.24 |
| **A3-1** | A3-1-2 | 0.46 | 0.47 | 0.46 | 0.41 |
| **A3-2** | A3-2-1 | 0.17 | 0.17 | 0.16 | 0.16 |
| **A4-1** | A4-1-2 | 0.23 | 0.22 | 0.20 | 0.22 |
| **A5-1** | A5-1-1 | 0.07 | 0.06 | 0.07 | 0.08 |
| **A6-1** | > A6-1-2 | 0.34 | 0.34 | 0.34 | 0.34 |
| **A7-1** | A7-1-2 | 0.42 | 0.33 | 0.38 | 0.36 |
| **A8-1** | > A8-1-2 | 0.35 | 0.35 | 0.35 | 0.35 |
| **A9-1** | A9-1-3 | 0.54 | 0.54 | 0.45 | 0.617 |
| **A10-1** | A10-1-1 | 0.18 | 0.21 | 0.23 | 0.16 |
| **A10-2** | A10-2-1 | 0.23 | 0.23 | 0.19 | 0.23 |
| **A11-1** | A11-1-1 | 0.25 | 0.22 | 0.22 | 0.29 |
| **A11-2** | A11-2-1 | 0.31 | 0.27 | 0.30 | 0.29 |
| **A13-1** | A13-1-1 | 0.16 | 0.11 | 0.16 | 0.27 |
| **A15-1** | A15-1-2 | 0.21 | 0.20 | 0.19 | 0.20 |
| **A15-2** | A15-2-2 | 0.20 | 0.19 | 0.19 | 0.21 |
| **A15-3** | A15-3-2 | 0.23 | 0.23 | 0.24 | 0.22 |
| **A15-4** | A15-4-2 | 0.27 | 0.24 | 0.23 | 0.24 |
| **A16 - 1** | A16-1-2 | 0.47 | 0.46 | 0.37 | 0.35 |
| _____ | A16-1-3 | 0.09 | 0.09 | 0.08 | 0.08 |
| **Totals** | Option A | **0.4719** | **0.4403** | **0.4790** | **0.4108** |
| | Option B | **0.4587** | **0.4293** | **0.4710** | **0.4031** |

The hierarchy can be rolled up to systematically determine the total potential value of the new innovation and the alternative product, which are shown at the bottom of Tables 7 and 8. According to Table 8, Brand 2 results in the highest absolute value, but a relative comparison is needed to accurately reflect the decision process of an individual, which will be shown in Table 9.

The new product serves several purposes, but the majority of the value is delivered via sub-objectives A4, A6, and A9. Each of these objectives rank similarly across each brand, which explains only a slight deviation in value classification across segmentations.

**Table 9:** Determination of the new product's potential value for users

| Option | Product | Entire Population | Brand 1 Population | Brand 2 Population | Brand 3 Population |
|---|---|---|---|---|---|
| **A** | Product 1 with the goal A16-1-2 | 0.4719 | 0.4403 | 0.4790 | 0.4108 |
| **B** | Product 1 with the goal of A16-1-3 | 0.4587 | 0.4293 | 0.4710 | 0.4031 |
| **C** | Alternative to Product 1 | 0.4272 | 0.3910 | 0.4354 | 0.3824 |
| | Percentage increase from A to C | **10.46%** | **12.6%** | **9.10%** | **7.43%** |
| | Percentage increase from B to C | **7.37%** | **9.80%** | **8.18%** | **5.41%** |

From Table 9, the potential value delivery in the new innovation results in a ~10% increase in potential value to the consumer. Ultimately, the potential value is highly dependent on the customer acceptance of the procedural change. Therefore, every effort should be taken to ensure the embodiment of the concept spurs user involvement to capture most of the value.

From the literature review, humans make evaluations based on alternatives. Hence, a percentage increase over the alternative products is an appropriate metric to make decisions. There appears to be a great fit between the new technology of option A and B to the market segmentation for Brand 1. Brand 2 would also benefit from the new product over the alternative product. Therefore, the new technology may be considered for a launch under Brand 1, or potentially Brand 1 and 2 to satisfy a larger customer base.

The level of risk associated with this project may be higher than other projects. Based on the scoping of the project, the potential value delivery is around 10%. Some of this potential value delivery will most likely be lost during translation from scoping to embodiment. The remaining

concept value will probably drive a small premium or slightly increase market share. Therefore, an appropriate market strategy and implementation can be planned accordingly.

## 4.5 Product 2 Value Assessment

The second product evaluation consists of a deviation from traditional products. The new product is considered a non-traditional product as it breaks from the traditional market place in attempt to open new revenue streams and grow the business ecosystem. As with the previous assessment, there is one system goal yet to be decided, A16-2. The new product will be assessed at the low end of the goals, A16-2-2, and the high end, A16-2-3. The low end will be referred to option A, and the high end will be referred to as option B. Therefore, comparisons to the traditional company products could not be made. The baseline was set based on an alternative which is currently under development and soon to be released, which will be called option C.

**Table 10:** Value assessment of the scope for option C on product 2

| Sub-Objective | Alternative Product Sub-Objective Goal | Score for Entire Population | Brand 1 Score | Brand 2 Score | Brand 3 Score |
|---|---|---|---|---|---|
| **A2-1** | A2-1-3 | 0.47 | 0.34 | 0.27 | 0.57 |
| **A2-2** | A2-2-3 | 0.66 | 0.64 | 0.64 | 0.68 |
| **A3-1** | A3-1-1 | 0.08 | 0.08 | 0.08 | 0.08 |
| **A3-2** | A3-2-1 | 0.17 | 0.17 | 0.16 | 0.16 |
| **A4-1** | A4-1-2 | 0.23 | 0.22 | 0.20 | 0.22 |
| **A5-1** | A5-1-1 | 0.07 | 0.06 | 0.07 | 0.08 |
| **A6-1** | A6-1-2 | 0.26 | 0.26 | 0.26 | 0.27 |
| **A7-1** | A7-1-1 | 0.08 | 0.07 | 0.09 | 0.07 |
| **A8-1** | A8-1-1 | 0.07 | 0.07 | 0.07 | 0.06 |
| **A9-1** | A9-1-1 | 0.11 | 0.10 | 0.09 | 0.10 |
| **A10-1** | A10-1-1 | 0.18 | 0.21 | 0.23 | 0.16 |
| **A10-2** | A10-2-1 | 0.23 | 0.23 | 0.19 | 0.23 |
| **A11-1** | A11-1-1 | 0.25 | 0.22 | 0.22 | 0.29 |
| **A11-2** | A11-2-1 | 0.31 | 0.27 | 0.30 | 0.29 |
| **A13-1** | A13-1-1 | 0.16 | 0.11 | 0.16 | 0.27 |
| **A15-1** | A15-1-2 | 0.21 | 0.20 | 0.19 | 0.20 |
| **A15-2** | A15-2-2 | 0.20 | 0.19 | 0.19 | 0.21 |
| **A15-3** | A15-3-2 | 0.23 | 0.23 | 0.24 | 0.22 |
| **A15-4** | A15-4-2 | 0.27 | 0.24 | 0.23 | 0.24 |
| **A16-1** | A16-2-1 | 0.42 | 0.31 | 0.41 | 0.40 |
| | | | | | |
| **Totals*** | | **0.3963** | **0.3478** | **0.4031** | **0.3373** |

* See appendix B for this calculation

Brand 2 has the highest absolute value for option C on product 2. While this segmentation values the innovation the most, they may not have the largest relativistic value when options A and B are assessed, as shown in Table 11.

**Table 11:** Value assessment of the scoping for option A and B on product 2

| Sub-Objective | Product 1 Scope for Sub-Objective Goals | Score for Entire Population | Brand 1 Score | Brand 2 Score | Brand 3 Score |
|---|---|---|---|---|---|
| **A2-1** | A2-1-2 | 0.40 | 0.34 | 0.61 | 0.57 |
| **A2-2** | A2-2-2 | 0.25 | 0.27 | 0.26 | 0.24 |
| **A3-1** | A3-1-2 | 0.46 | 0.47 | 0.46 | 0.41 |
| **A3-2** | A3-2-1 | 0.83 | 0.83 | 0.84 | 0.84 |
| **A4-1** | A4-1-2 | 0.23 | 0.22 | 0.20 | 0.22 |
| **A5-1** | A5-1-2 | 0.37 | 0.34 | 0.32 | 0.33 |
| **A6-1** | > A6-1-2 | 0.35 | 0.35 | 0.35 | 0.35 |
| **A7-1** | A7-1-2 | 0.42 | 0.33 | 0.38 | 0.36 |
| **A8-1** | A8-1-1 | 0.07 | 0.07 | 0.07 | 0.06 |
| **A9-1** | A9-1-1 | 0.11 | 0.10 | 0.09 | 0.10 |
| **A10-1** | A10-1-2 | 0.82 | 0.79 | 0.77 | 0.84 |
| **A10-2** | A10-2-1 | 0.23 | 0.23 | 0.19 | 0.23 |
| **A11-1** | A11-1-1 | 0.25 | 0.22 | 0.22 | 0.29 |
| **A11-2** | A11-2-1 | 0.31 | 0.27 | 0.30 | 0.29 |
| **A13-1** | A13-1-2 | 0.55 | 0.57 | 0.58 | 0.42 |
| **A15-1** | A15-1-3 | 0.72 | 0.73 | 0.74 | 0.73 |
| **A15-2** | A15-2-2 | 0.20 | 0.19 | 0.19 | 0.21 |
| **A15-3** | A15-3-2 | 0.23 | 0.23 | 0.24 | 0.22 |
| **A15-4** | A15-4-2 | 0.27 | 0.24 | 0.23 | 0.24 |
| **A16 - 1** | A16-2-2 | 0.50 | 0.59 | 0.49 | 0.51 |
| ____ | A16-2-3 | 0.09 | 0.10 | 0.09 | 0.09 |
| **Totals** | Option A | **0.5398** | **0.4900** | **0.5357** | **0.4739** |
| | Option B | **0.5255** | **0.4754** | **0.5249** | **0.4617** |

The strategy of the new product was to capitalize on improving objectives A3, A5, and A15. Brand 2 provides the highest absolute value to consumers, but in order to accurately reflect a human's evaluation of a new product, a relative comparison must exist.

**Table 12:** Determination the new product's potential value for users

| Option | Product | Entire Population | Brand 1 Population | Brand 2 Population | Brand 3 Population |
|---|---|---|---|---|---|
| **A** | Product 1 with the goal A16-2-2 | 0.5298 | 0.4900 | 0.5357 | 0.4739 |
| **B** | Product 1 with the goal of A16-2-3 | 0.5255 | 0.4754 | 0.5249 | 0.4617 |
| **C** | Alternative to Product 1 | 0.3963 | 0.3478 | 0.4031 | 0.3373 |
| | Percentage increase from A to C | **33.69%** | **40.89%** | **32.90%** | **40.50%** |
| | Percentage increase from B to C | **32.60%** | **36.69%** | **30.22%** | **36.88%** |

The potential value for this product exceeds the baseline product of the next best alternative, as well as improvements in other areas. The general population tended to have a higher absolute value for this new product, which was greater than the individual market segmentations. Using a relativistic assessment, which reflects an individual's actual thought process, results in a greater technology to brand fit for Brands 1 and 3.

In this case, the risk for this new product would not come from the potential value delivery. The potential value of the new product exceeds the alternative product by almost 30%. Rather, the risk comes in the form of a non-traditional product launch. The success of the value delivery is dependent on the users adoption of the new product methodology into their current operation. Appropriate strategies can be determined based on this front loaded design information.

# 5 Future Work and Conclusions

## 5.1 Future Work

As with all models, this methodology is not perfect. In fact there are some key areas for improvement which may lead to future work. The issues that arose came from several sources, but tended to be procedural difficulties and limitations of the model

The prodedural difficulties are a result of the administration of the survey. One of the largest obstacles to overcome for such a methodology is the communication barriers between engineers and customers. The gap is often frustrating and can lead to incorrect results if not accounted for.

Customers typically think in terms of how they operate their current products, and what their needs are in context of their habitual procedure. Thus they cannot express potential unmet needs because they have not been trained or have the experience to do so. While engineers are trained to predict future trends and anticipate potential market shifts due to new technology and/or discoveries, not to mention the context of their messages are typically technically sophisticated and detailed.

The result is a communication barrier due to customer and engineers communicating from the ends of two spectrums. The first spectrum is the time dependent, where customer speak from their habitual use context, and engineers speak from a futuristic use context. The second spectrum is the message to be communicated. Customer typically speak of qualitative messages which may be vague, while engineers tend to communicate in quantitative, concrete messages.

This phenomeneon plays a large role in the methodology which was outlined, especially when creating the customer surveys. One of the largest detrimental impacts is customers are unable to to embody a concept which may be a futuristic trend. This issues occurred on some of the goals for sub-objectives in the hierarchy. These futuristic trends tended to involve some modification to traditional habits for operation, and resulted in a lower score for how consumers would value the specific goal.

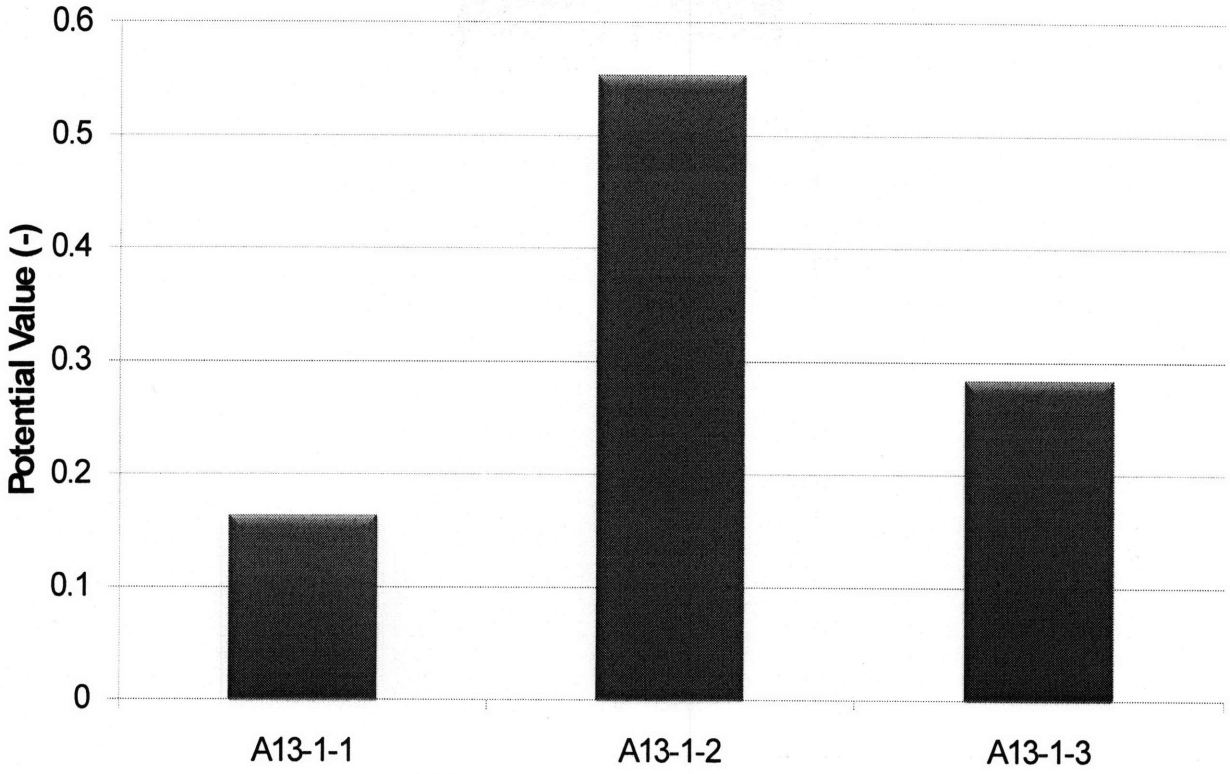



**Figure 25:** Illustration of a disconnect in communication between customers and engineers

Figure 25 attempts to provide an example of this phenomenon. Engineers consider goal A13-1-3 to be a futuristic trend which the marketplace is headed towards and believe it will deliver a lot of value to customers once it is adopted. Yet in the current landscape, it is less valued than goal A13-1-2, which has less performance and adds inconvience, but it is reflective of the current habits of customers.

The other area which warrants a discussion is the limitation of the model. The original plan for this work was to assess three different products based on their level of change to the current industry. The first product is an incremental change with only a small change in habits, the second is a non-traditional product which attempts to grow the revenue base of the existing marketplace, and the third was a radical innovation which requires a large shift in the current architecture as well as a large change in customer habits.

The first two products worked well with the model as demonstrated in the application of the methodology. The model did not work well with radical innovation. The largest issues arose from the communication barrier as previously mentioned because customers failed to realize the embodiment of the radical concept, which is to be expected.

Clark and Henderson (1990) have researched the idea of architectural innovation, and their work indicates a reason for the model's failure to assess radical innovation. They define the potential of radical innovation to redefine an industry. With a redefintion, the core concepts are changed which results in a shift in how customers value a product. Predicting the futuristic value structure of a market place is not possible based on this methodology.

The final limitation of the model is that the methodology only provides a snap-shot of a market at one point in time. Value structures can change overnight based on the speed of products to market and external factors which are out of the control of the company, such as a competitor's advertising campaign. Therefore, there is a window for which the model is accurate before the process has to be repeated in order to verify the new marketplace.

In summary, there are three potential areas for future work.

- The first is an extension of what has been previously discussed. The market survey was created in the customer terminology as to illicit feedback which accurately reflects their needs structure. Engineers would find it beneficial to translate these needs back to engineering requirements and specifications. QFD techniques have been shown to be used with popularity amoung the engineering community. But there needs to be further work to ensure the requirements which are in a QFD accurately portray the customers thought process, and information is not lost in translation.

- Second, the limitation of the current model is the fact that it depends on historical information. The model measures what customers value in the current products. An interesting piece of work would evaluate a project in a forward facing direction in time. This would help probabalistically assess trends and how the value structures will dynamically change over time with new technology.

- The final area for future work is related to the second area. Since there is a need to understand futuristic needs, there is a need to understand how radical innovation will be valued in the future marketplace. A model similar to the methodology outlined here which could measure the probability of a value structure to be overturned and restructured based on a new technology would provide some interesting insights into the market dynamics, especially markets with a fast clock-speed.

## 5.2 Conclusions

For completeness, revisiting the initial research questions from the introduction is warranted.

> *When evaluating a new product, how do consumers set objectives, and more importantly, how do they use those objectives to evaluate the product?*

Consumers set their objectives based on their value taxonomy and their current use habits of their traditional products. Humans observe multiple inputs and transform them into internal representations which are based on their goals. These internal representations drive a customer's decision.

> *How do we measure the preferences of a marketplace to determine the relative value of a new innovation to a customer base?*

By measuring an individual's opportunity cost for each objective, it is possible to determine the relative value for a new innovation. The comprehensive objectives can be placed in a model to assess the potential value of a new product.

> *Can the front loaded value evaluation also measure the potential value to multiple market segmentations?*

Yes, by identifying the top objectives of each market segmentation, it is possible to determine the individual value structure. As demonstrated, a value assessment can be made for consumers in general, as well as each individual market segment.

> *How can this technique be used to align a technology with a brand strategy?*

With the value assessment of each market segment, a relative comparison can be made with existing products. Attributes which increase value of existing products shows a good technology to brand fit.

The methodology outlined can generate unique insights into a competitive market place. The procedure can provide a distinct competitive advantage for a company to assess new product innovation in a different perspective than the traditional sales forecasting. They can measure the potential value delivery of a new innovation before a sketch is even made based on the scoping of the project.

This producedure has been shown to be viable for incremental innovations and non-traditional products which expand the product base. For new products which change customer value structures and reshape a market, the methodology does not hold merit. This methodology makes value assessments based on existing value structures of what consumers currently value in their products. Radical innovation creates a dynamic market where the value structures are overturned and consumer value their products differently.

By combining principles from psychology, engineering, and marketing, the methodology takes the ambiguity surrounding the combination of these principles and reduces into a simplistic algebraic equation. Combining these inputs and driving out the ambiguity provide a systematic solution to scoping new product development strategies.

# Appendix A

## Sample Matrix Calculations

The data calculations are best shown with an example. For simplicity, this will only demonstrate the first level calculations. This example will take into context the marketplace for mobile handsets. For the sake of discussion, only three objectives matter to consumers: increasing battery life, increasing screen size, and increasing the feature set. In order to complete the matrix, a designer would have to receive feedback on three questions: battery life compared to screen size, battery life compared to feature set, and screen size compared to feature set.

From the responses in the questionnaire, a distribution can be fit to match the respondents' answers. This can be done using software such as Chrystal Ball. The distributions are then placed in the matrix for manipulation. Here is a set of potential values for sake of discussion.

*Battery life is 7 times more important than screen size.*
*Battery life is 5 times more important than feature sets.*
*Feature sets are 3 times more important than screen size.*

The resulting matrix is:

| | | O1 | O2 | O3 |
|---|---|---|---|---|
| Battery Life | O1 | 1 | 7 | 5 |
| Screen Size | O2 | 0.2 | 1 | 0.33 |
| Feature Set | O3 | 0.5 | 3 | 1 |

The diagonal of the matrix is populated with values of unity. The off-diagonal entries are a result of the survey, and the reflective entries are simply inverse values. It can be read across the row and then up. So to interpret, Feature Set is three times more important than Screen Size. Or Screen Size is one third more important than Feature Set.

The first step of the operation is to normalize the entries by the sum of their column.

| | | O1 | O2 | O3 |
|---|---|---|---|---|
| Battery Life | O1 | 1 | 7 | 5 |
| Screen Size | O2 | 0.14 | 1 | 0.33 |
| Feature Set | O3 | 0.2 | 3 | 1 |
| SUM | | 1.34 | 11 | 6.33 |

The normalized matrix is:

| | | O1 | O2 | O3 |
|---|---|---|---|---|
| Battery Life | O1 | 0.74 | 0.64 | 0.79 |
| Screen Size | O2 | 0.11 | 0.09 | 0.05 |
| Feature Set | O3 | 0.15 | 0.27 | 0.16 |

Where 0.74 is position (1,1) is equal to 1/1.34.

The approximation of the principle vector is the average across a row. For this matrix, the principle vector is:

| | | Principle Vector |
|---|---|---|
| Battery Life | O1 | 0.72 |
| Screen Size | O2 | 0.08 |
| Feature Set | O3 | 0.19 |

The principle vector represents how the individuals who completed the questionnaire value the objectives associated with a mobile handset. The respondents value the features of a new phone twice as much as the screen size, and favor battery life almost four times more than the feature set. The distribution of these values has been omitted for this example. Since the principle vector is based off answers with a distribution, the values in the principle vector will have a distribution as well.

The final step is to determine the consistency of responses from the survey to ensure accuracy of the data. This involves calculating the consistency ratio by performing additional matrix operations. The first step is to multiply the original matrix by the calculated principle vector.

| | O1 | O2 | O3 | | Principle Vector | | |
|---|---|---|---|---|---|---|---|
| O1 | 1 | 7 | 5 | | 0.72 | | 2.28 |
| O2 | 0.2 | 1 | 0.33 | X | 0.08 | = | 0.25 |
| O3 | 0.5 | 3 | 1 | | 0.19 | | 0.59 |

The new matrix is normalized by the corresponding entry in the principle vector. The results are:

| Principle Vector | | |
|---|---|---|
| 2.28/0.72 | | 3.14 |
| 0.25/0.08 | = | 3.01 |
| 0.59/0.19 | | 3.04 |

An approximation of the maximum eigenvalue is the average of the entries in the resultant matrix. Thus in this case, the maximum eigenvalue is 3.066.

The consistency index, CI, is calculated from the maximum eigenvalue, $\lambda_{max}$, and the number of objectives tested in the questionnaire, N. The Equation is:

$$CI = \frac{\lambda_{max} - N}{N - 1}$$

$$CI = \frac{3.066 - 3}{3 - 1} = 0.033$$

The consistency index must be normalized by the random index, RI, which is based on N. The random index is a measure of deviation from consistency from random samples with equal number of objectives. The random index can be calculated fro the table below.

| N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

In the example, the RI is equal to 0.58. Thus the consistency ratio, CR, is:

$$CR = \frac{CI}{RI} = \frac{0.033}{0.58} = 0.057$$

As previously mentioned, Saaty (1980), who pioneered the entire calculations shown in this appendix, states that answers which generate a consistency ratio of less than 0.1 are considered consistent. Thus in this example, the answers given to the questionnaire are entirely consistent, and can be considered accurate.

# Appendix B

## Sample Hierarchy Calculations

The calculations in this appendix will provide a demonstration to calculate the total potential value. In order to do so, simple calculations are sequentially performed to roll up the tree. All the calculations provided are modified from work done by Saaty (1980).

For this example, consider it is important to understand the value structure for new computers. Also for demonstration, consider there are three major objectives which are important in the purchase intent: storage capacity, processor speed, and monitor size. For storage capacity there are a range of potential goals: 100 GB, 500 GB, and 1 TB. For processor speed there are a range of potential goals: 2.0 GHz, 2.4 GHz, and 2.8 GHz. For monitor size there are a range of goals, 20 inch, 24 inch, and 27 inch.

A survey can be conduct to determine the prioritization for the tree as shown in Figure B.1.

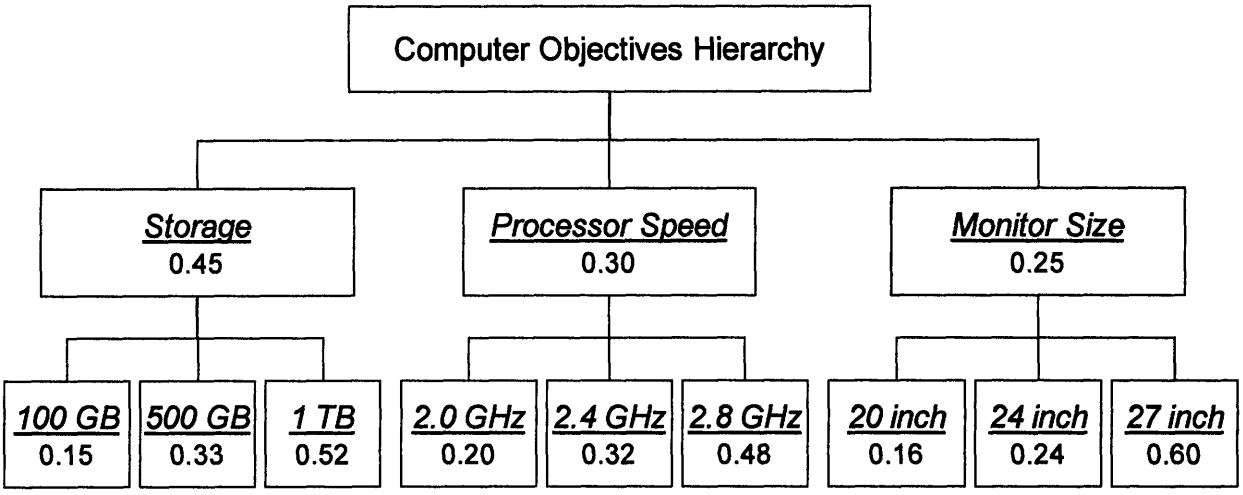



**Figure 26:** Hierarchy for an example problem

With this information, a computer development company can assess the potential value by scoping a new computer configuration. For their computer, they scope the initial parameters to be a 500 GB hard drive, a 2 GHz processor, with a 27 inch monitor. These selections follow the value tree structure as shown in Figure B.2.

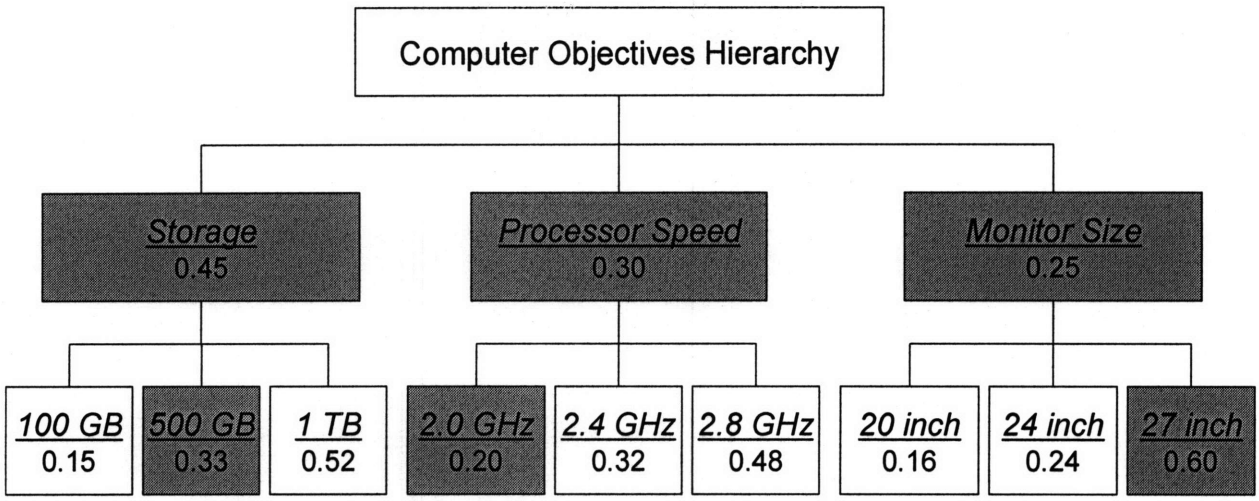



**Figure B.27:** Scoping of the computer example

Therefore, the potential value of the new computer configuration is as follows:

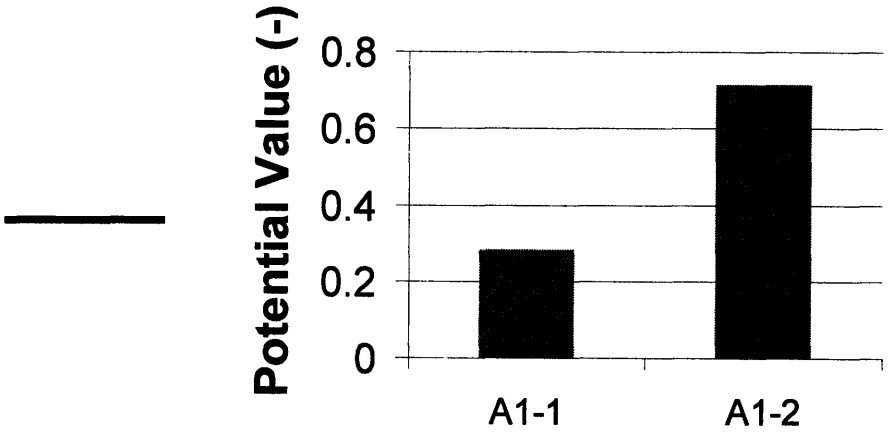
$$V = 0.45 * 0.33 + 0.3 * 0.2 + 0.25 * 0.60$$

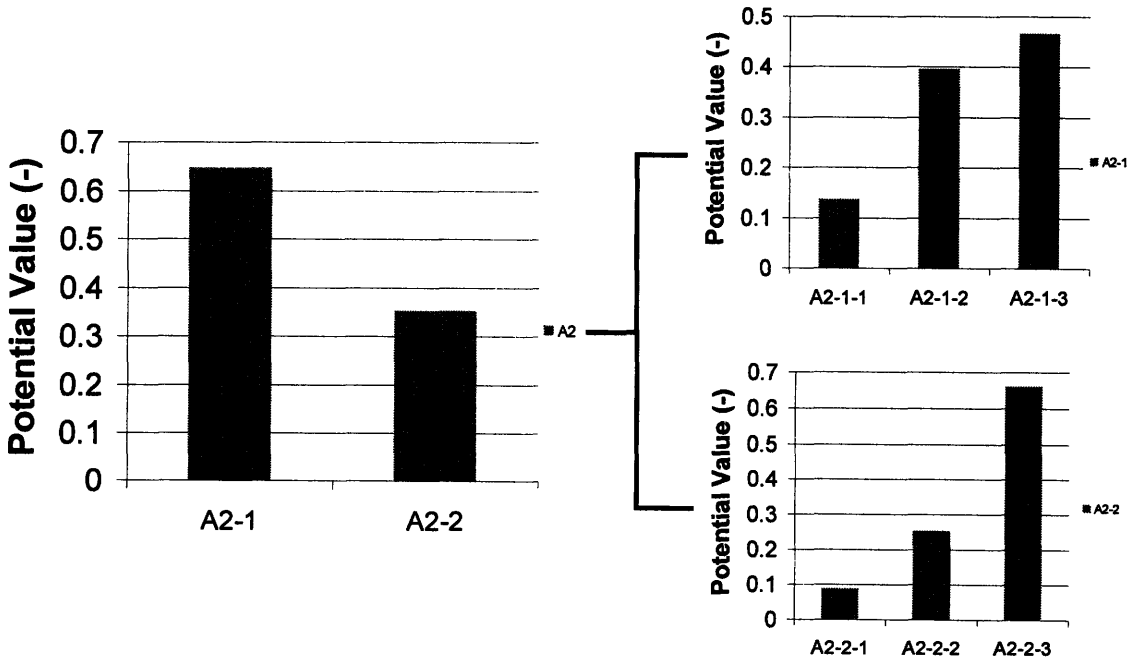
$$V = 0.3585$$

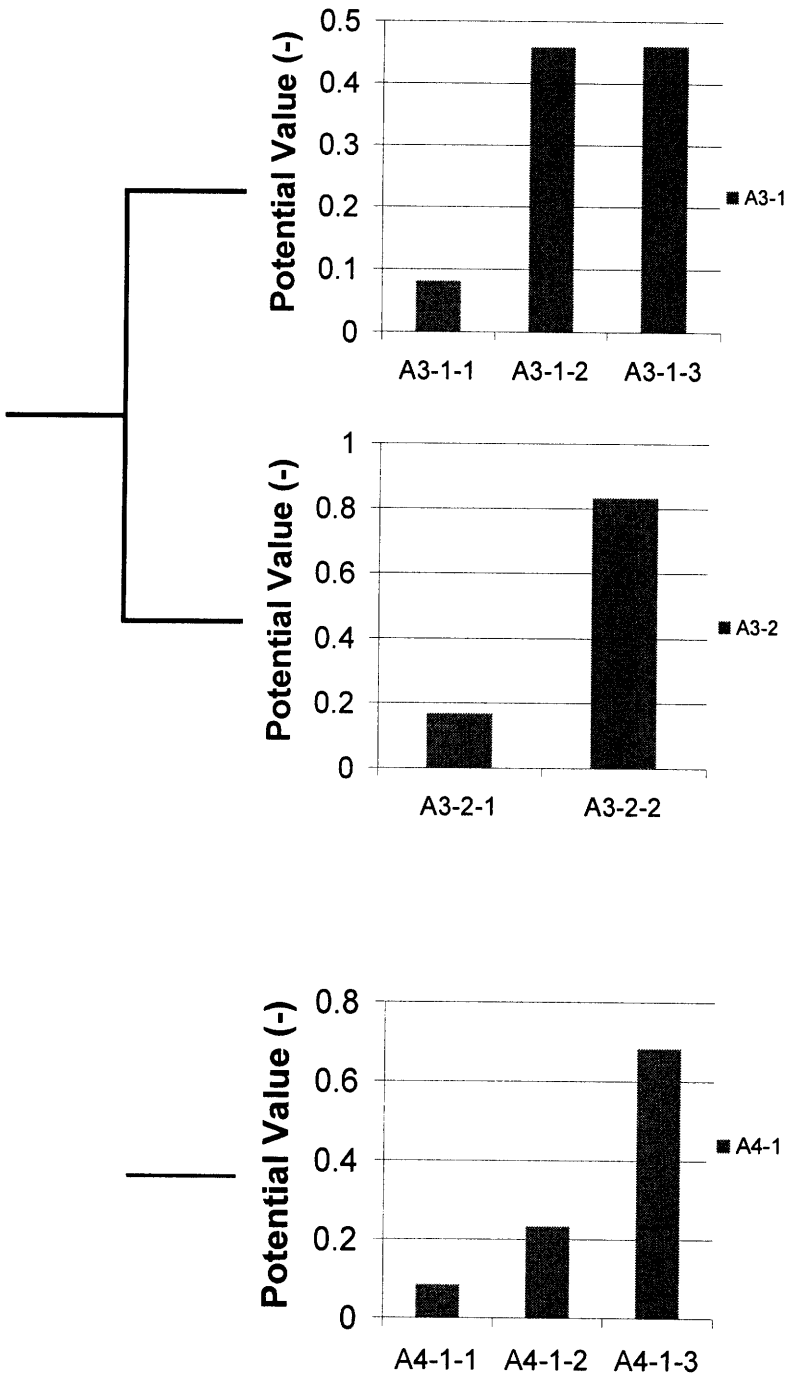
# Appendix C

## Survey Data

This appendix is provided to show all of the data results from the survey. All of the questions were randomly dispersed over six surveys. 491 consumers filled out a survey for roughly 80 consumers per question. For organizational purposes, the data will be presented in the hierarchy. Due to the horizontal size of the hierarchy, the lines to the left of the diagrams will show that there is a direct linkage to the top level objective.

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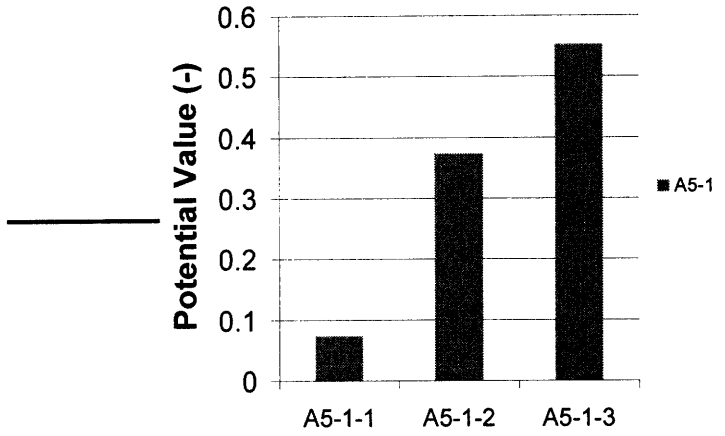
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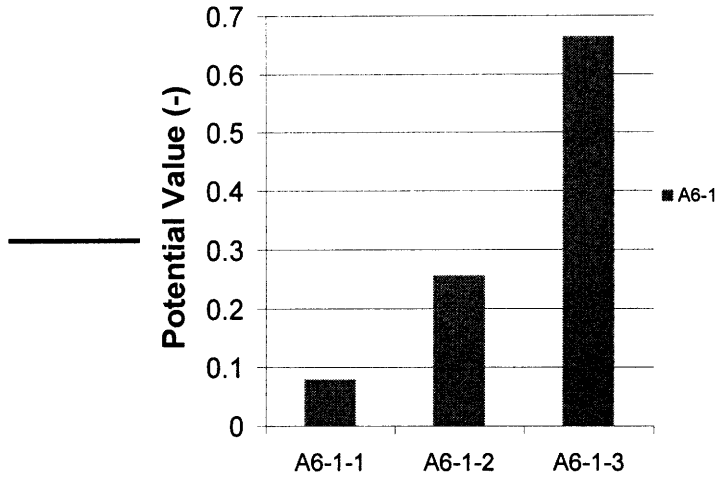
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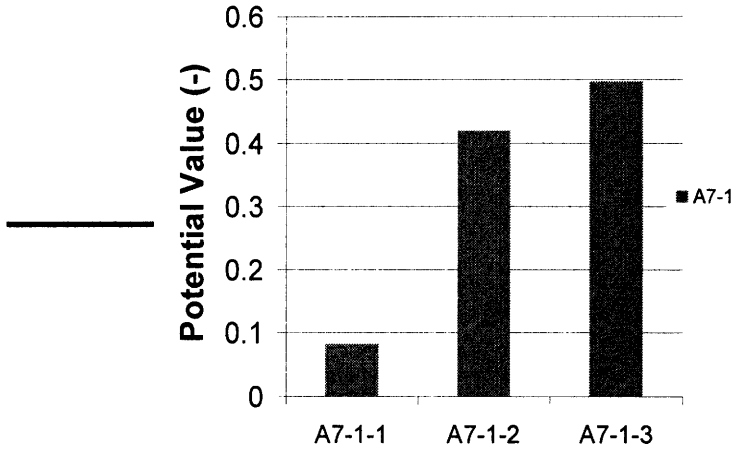
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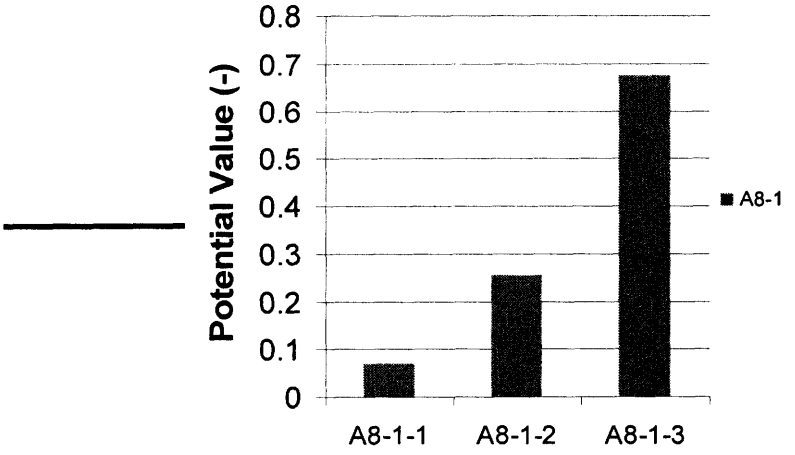
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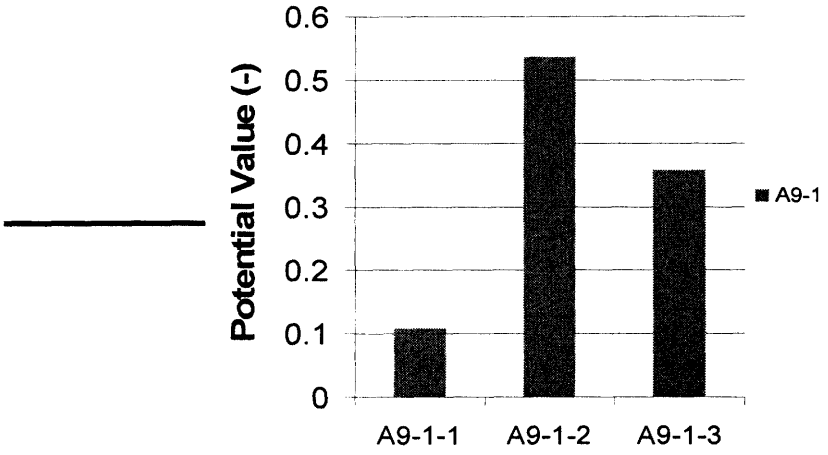
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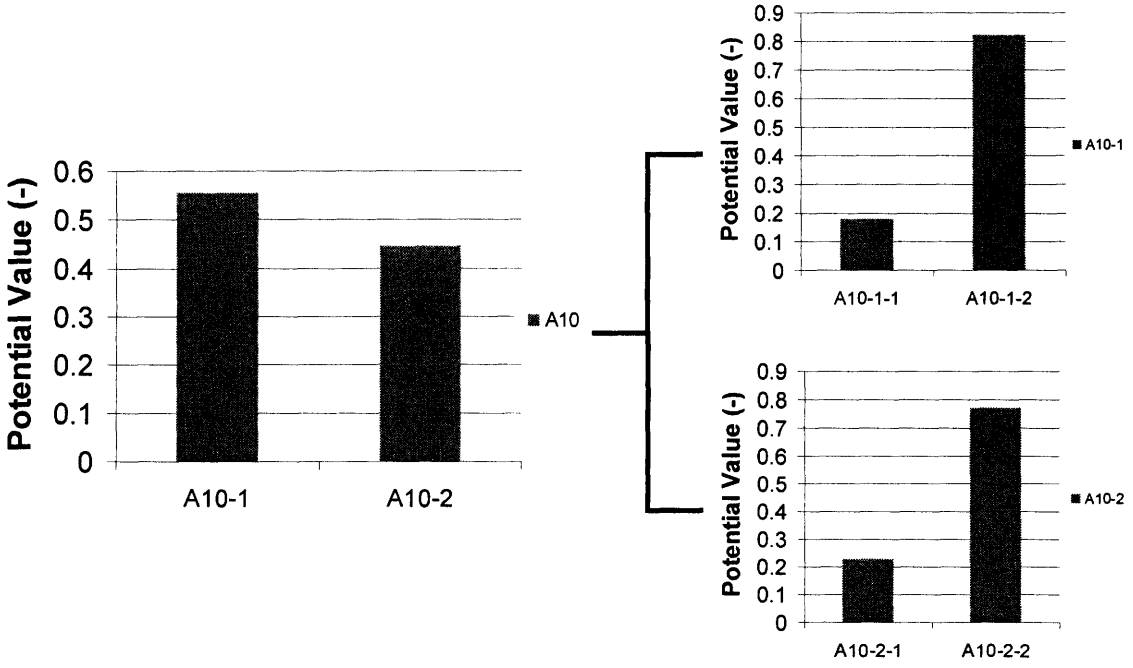
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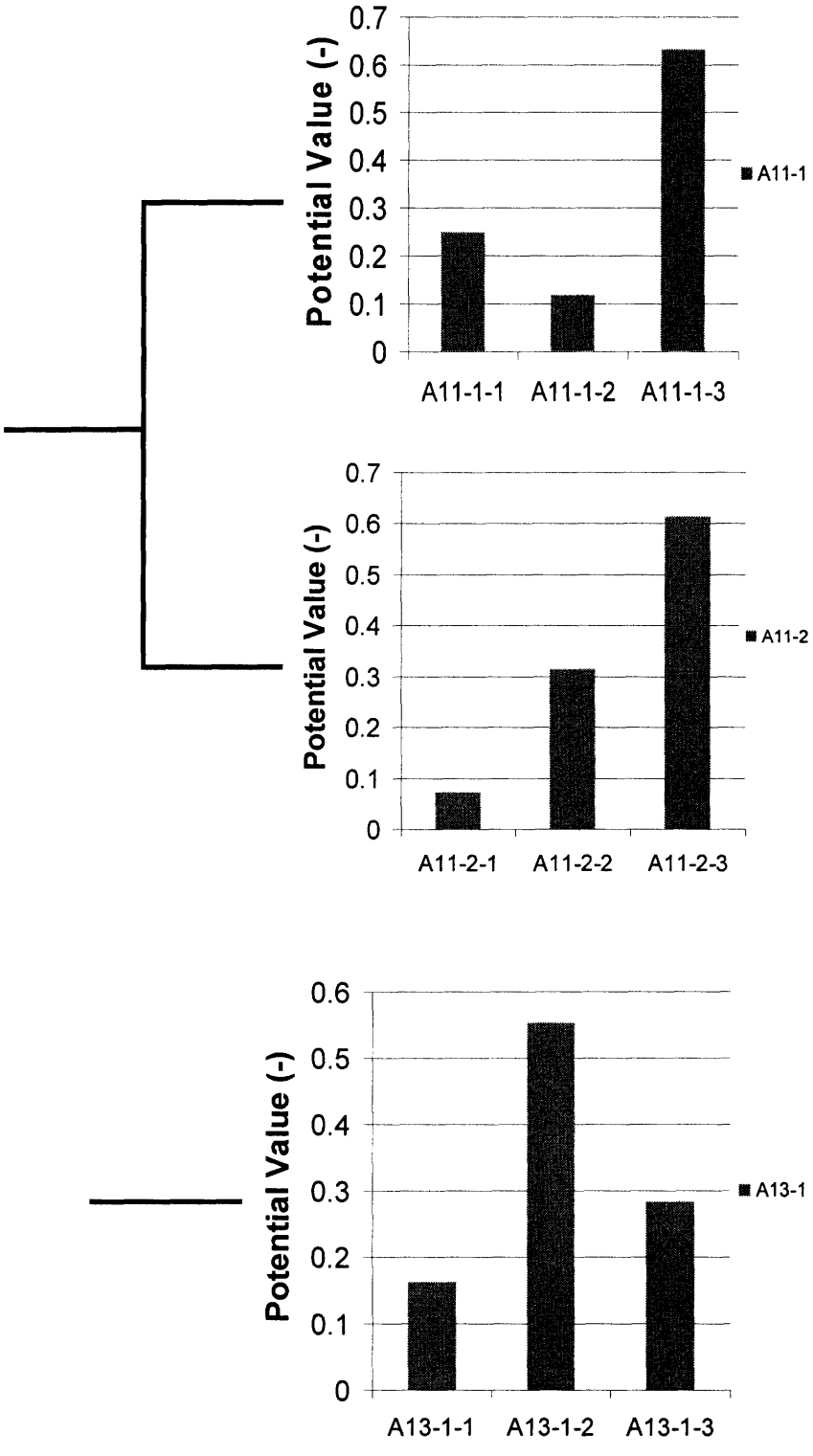
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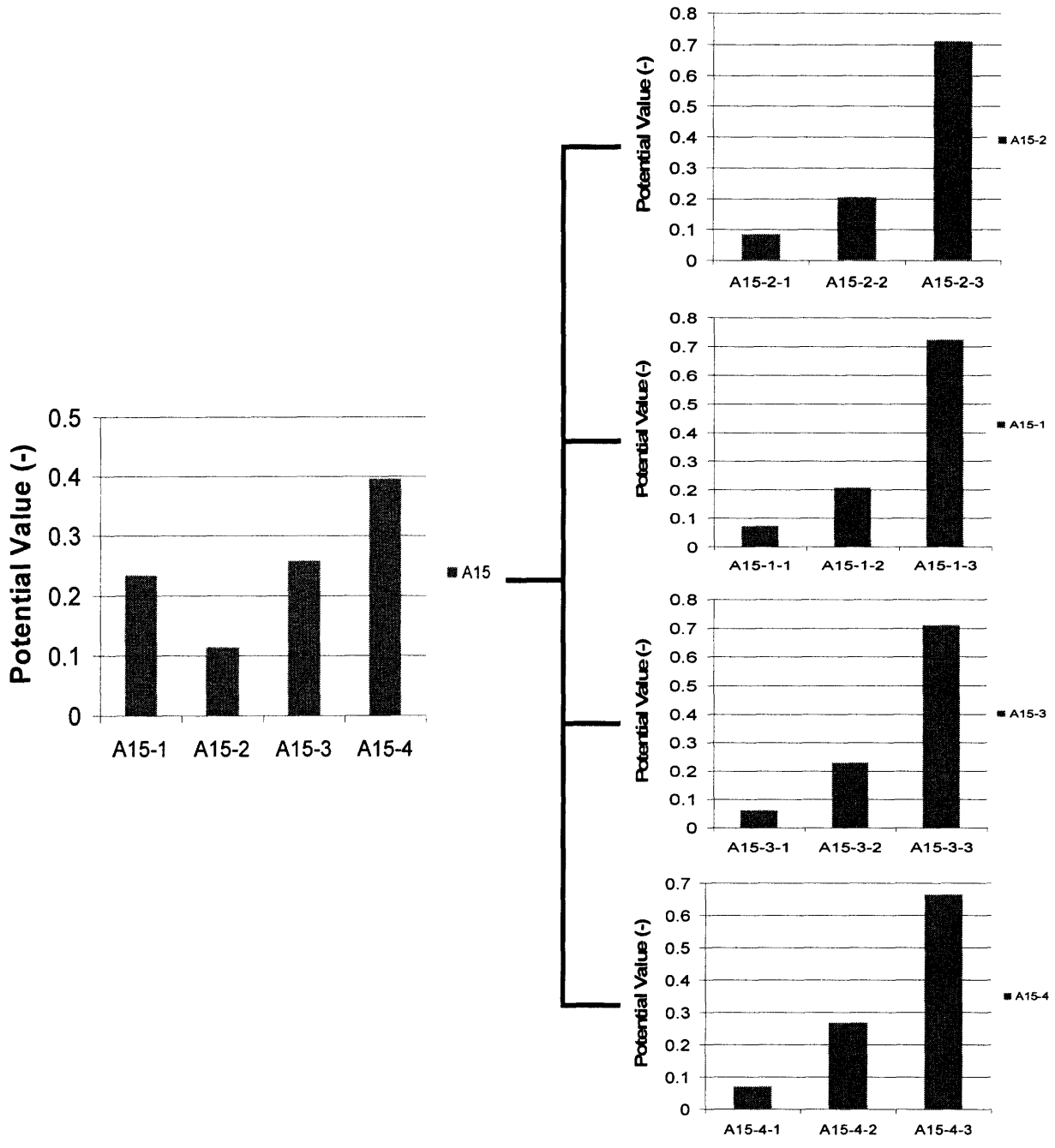
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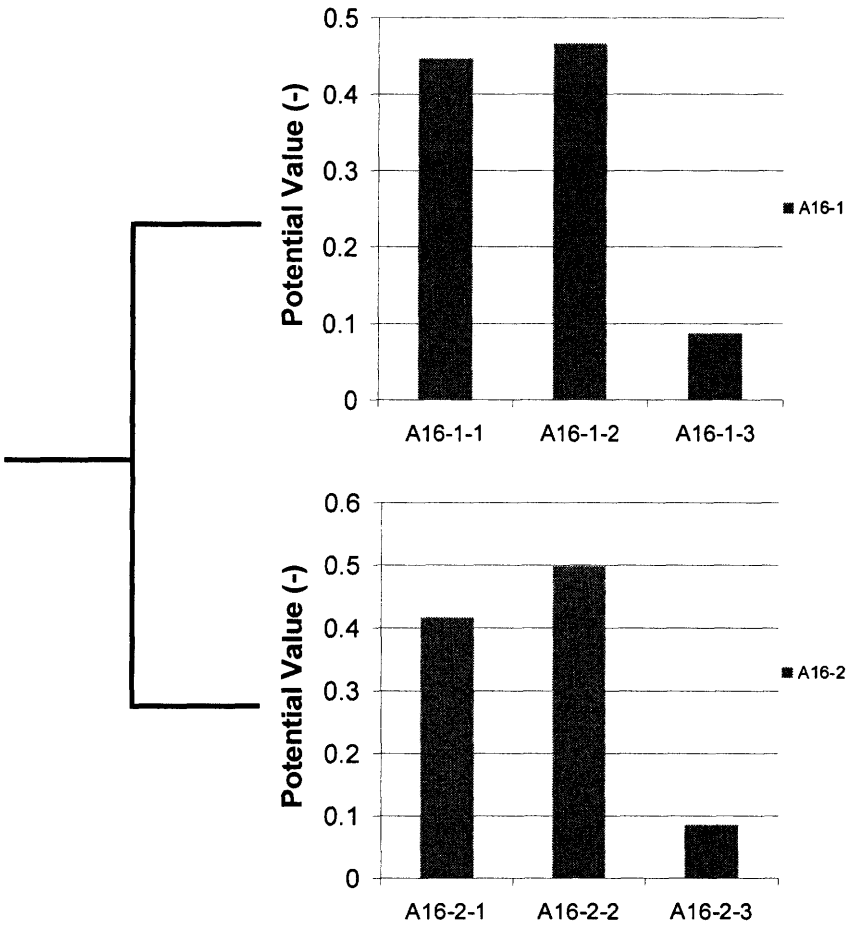
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