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# Concept Design for Creating Essential Hypothesis, Rules, and Goals: Toward a Data Marketplace

Jun Nakamura [A], Masahiko Teramoto [B]

[A] Kanazawa Institute of Technology, 1-3-4 Atago, Minato-ku, Tokyo 105-0002 Japan, jyulis@neptune.kanazawa-it.ac.jp
[B] ex-Volvo Group Trucks Technology, masa.teramoto@gmail.com

## ABSTRACT

*The abductive reasoning model has been discussed in the context of business strategy. However, this model seems unrealistic for applications in the real business world considering the unpredictable, competitive business environment. This study improves the model by formulating an experimental case study through a web-based workplace for generating product ideas. We discuss the possible embodiment of product ideas as the basis for configuring features through the use of dynamic quality function deployment. The entire concept design process is proposed as a blueprint for building a data marketplace.*

## TYPE OF PAPER AND KEYWORDS

Short communication: *abduction, generating ideas, data marketplace, quality function deployment*

## 1 INTRODUCTION

Differentiation is a fundamental business strategy to address competitive factors [11, 4]. On examining the successful business strategies followed by companies such as Disney [1], Starbucks [2], and Google [3], each offering has its own context and unique stories through which essential hypothesis and rules are created. This results in goals distinct from those of their competitors despite uncertain external information and data when designing business strategy. Similar features emerge when participants in a data marketplace take actions to generate new ideas. To address this concern, this study attempts to answer the following two research questions:

1. How will the new idea (as a goal) along with the hypothesis and rules be formulated simultaneously with limited information or data?
2. How will the outcome of any new ideas generated be embodied in a tangible form as a concept design?

To answer the former question, we introduce an empirical environment called *Kotofactory*, which is able to record action logs in sufficient detail to facilitate the examination of the process of idea generation. The empirical environment as a tool for

[1] http://www.disney.com/
[2] http://www.starbucks.com/
[3] http://www.google.com/

supporting creative activities [2] elucidates the first question to some extent. Although the data volume is limited, we shall focus our knowledge and databases to complement the data to polish participants' intuition. The challenge here is how to reconstruct the data already known as well as how to utilize this knowledge to achieve the goal as new ideas in order to design a data marketplace. In this study, the data marketplace is defined as an environment that helps both data providers and data requesters retrieve the data's value by means of combination, reconstruction, or reinterpretation of the data through the exchange of shared data profiles as well as to ensure that the possible concept design is as practical as possible.

To answer the second question, we introduce dynamic quality function deployment (DQFD), which is a framework to find optimized numeral and time series variables of market requirement, quality characteristic, and design specification that shall be commonly related with each other to design a tangible form. These three factors are sometimes conflicted, e.g., longer distance as a market requirement of electric vehicles, 500 km per one battery charge as a quality characteristic, but the battery shall be bigger and heavier and only few people can ride the electric vehicles as a design specification. Therefore, we are requested to consider and identify the distance and size of battery the market can get using DQFD. We refer to DQFD as a framework *Kotoframe* in this study. It is used in the manufacturing industry for concept design, and we assume that Kotoframe would support the process of embodying high-level ideas into tangible forms, thus answering the second research question.

The rest part of this paper is organized as follows. The following section introduces the related research. Section 3 explains the experimental method to implement Kotofactory. In Section 4, we provide details of the results. Section 5 discusses a case study on how the hypotheses, rules, and goals generated by Kotofactory would be formalized. Finally, we discuss the consecutive "Koto" series as an input for designing an effective data marketplace.

## 2 RELATED RESEARCH

We introduce previous research relative to abductive reasoning, Kotofactory, and Kotoframe in this section. The former one includes related studies by other authors, and latter ones are the previous research of the authors.

### 2.1 Abductive Reasoning

Abductive reasoning is utilized in the context of discovery, thus using existing knowledge and given datasets to draw conclusions, make predictions, and formulate hypotheses and rules. An inference consists of deduction, induction, and abduction. Abduction develops hypotheses and rules in the context of discovery, whereas induction is a manipulation for empirically testing hypotheses and rules, derived from abduction, in the context of justification [10]. In other words, hypotheses and rules derived from abduction are different from those observed directly, and induction involves inducing the existence of phenomena similar to those observed.

Therefore, abductive reasoning contributes to the discovery of hypotheses and rules, which could be considered as a method of generating new ideas. In the process of abductive reasoning, the first step is to search for possible hypotheses, and the second step is to identify the best hypothesis from the pool of possibilities by activating one's inference in consideration of overall integrity. Peirce points out that the best hypothesis in the second step should be evaluated on the basis of plausibility, verifiability, simplicity, and economy [10].

Abductive reasoning has been modeled for formulating a business strategy, as shown in Figure 1, depicting three business cases, Starbucks, IKEA [4], and Coca-Cola [5] [6]. The model in Figure 1 shows that in the event that an observed fact *F* is given, ideas generated as option *A* passed on to *B*, which is inferred in the context of rule 1. In contrast, option *X* implies *B′* instead, which was initially an unexpected idea but was discovered by abductive reasoning in the hypothetical context based on rule 2, enabling the achievement of goal *C*.

However, business strategy and/or generating ideas in the real world might become more complex depending on the competitive environment and other external factors like a technological revolution, which brings rapidly changing services associated with a growing rate of internet access around the world. Thus, the issue faced when generating new ideas is that the goal itself could be uncertain or ill-defined and even

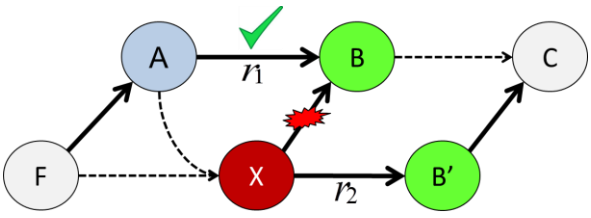


**Figure 1: Abductive reasoning model of previous research**

[4] http://www.ikea.com/
[5] http://www.coca-cola.com/global/glp.html

diffused with various types of noise, which makes it difficult to understand what is intrinsic to the company in terms of its attractiveness in the market. The data marketplace would create a similar situation where participants need to create hypotheses, rules, and goals as well, which needs to be rather innovative.

## 2.2 Kotofactory

Kotofactory is a web-based game that serves as an empirical environment, which has been developed to stimulate players' abductive reasoning and generate new product ideas [5]. It is called a "game" expecting psychologically lower players' level of entry to web based experiment in comparison with something called a test or experiment because those would lead players to expect that their natural cognitive process will be judged. A game has two elements:

- Enjoying while playing it online, free from limitations of space and time, and
- Ill-defined goals, as in SimCity [6], which is not about winning or losing.

Kotofactory is an empirical environment for testing cognitive and hypothetical reasoning simply by showing two different products from different industries along with their components consisting of several pieces. This method was chosen because in real business fields, employees developing new product ideas tend to concentrate on their own products from their own industry, avoiding ideas from different products in different industries.

For example, experts on automotive engine sensor product development would ignore the needs of sensors in the entertainment industry such as in products similar to Nintendo's Wii [7]. Therefore, Kotofactory introduces the most simplified method to incorporate two different products in an empirical trial. These ideas can be considered at an initial stage for concept design in product planning in order to overcome stereotypical thinking and thus improve a firm's chance of differentiating itself from others.

By introducing Kotofactory in the concept of abductive reasoning, the path from being given unstructured data to forming the goal can be visualized and reproduced using the game's play log with sufficient details to enable analysis on how hypotheses and rules as well as the goal are composed. The method of using Kotofactory is detailed in Section 3.

[6] http://www.simcity.com/

[7] http://www.nintendo.com/wiiu

## 2.3 Kotoframe

QFD, developed by Akao and others [3], simplifies concept design by deploying identified functions in terms of product traits such as durability, maintainability, and/or adaptability to the market. QFD supports efforts to determine design specifications along with offering a mechanism to ensure conformity with market requirements. DQFD [12, 13], known here as Kotoframe, has been developed as a tool for concept design to support players (or designers) to solve simultaneously rising problems where the solution to one will impact the solution to the other. Examples include market requirements and design restrictions.

This method facilitates decision making in product planning. For example, the market for electric vehicles expresses two different needs, namely, longer range (distance) and lower costs at the same time. However, meeting these two market requirements creates conflict because a battery system should be heavier to satisfy the former requirement but lighter to satisfy the latter requirement. Thus, Kotoframe facilitates the process of figuring out how to reconcile such conflicts to arrive at solutions.

Once the solution is resolved by means of trial and error, it shall be examined and refined in light of market requirements. This in turn generates ideas to be improved and/or elaborated upon further, by utilizing Kotofactory again. Hence, the proposed model could be operated in several rounds and in a type of double helical model [9]. The Kotoframe's final target is to embody Kotofactory's output into tangible forms as concept designs in a product planning process. The relationship between Kotofactory and Kotoframe is discussed in Section 5.

# 3 METHOD

In this section we introduce empirical environment and data on the experiment.

## 3.1 Empirical Environment

A web-based process called Kotofactory has been developed to study how *framed* components are generated by combining different products, which is considered useful when designing a data market-place [5]. As shown in Figure 2, on the left side of each component for a given product, we can see three elements, which are *way to use*, *function*, and *material/infrastructure* given in different colors. A different product is shown in the same manner on the right side. Accordingly, product A's *function* could be applied to product B as its *way to use*, whereas product

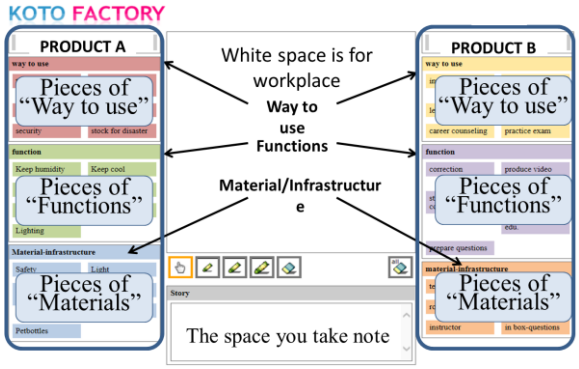


**Figure 2: Screen Image to start playing the game**

B's *material* could be applied to product A's *function*, depending on the case.

Administrators have the ability to edit bilateral product names, component names, number of components (maximal 5 elements per product: three components are shown in Figure 2), component colors (to be selected from 10 given colors), and component pieces (maximal 6 pieces). Players can engage in building combinations and relating cards to a cluster by dragging components from both sides via lines and arrows in the workplace at the center of the screen.

In this way, framed thinking is assumed to generate new product offerings comprising restructured components utilizing relevant and selected pieces. A previous study has demonstrated that such a frame-design workplace facilitates new product ideas by restructuring pieces of components from different products [5]. Notes can be made at any time during the game in order to record created ideas or scenarios. The space to take notes can be found at the bottom of screen, as shown in Figure 3.Kotofactory has been upgraded so that all log data can be saved automatically to enable reproduction of all processes that the players performed during the experiment.

Two additional screens were prepared. One screen, as depicted in Figure 4, asks players about *who* the customers/markets are, *what* product ideas are generated, and *why* the product is competitive. These questions are displayed immediately after finishing the game. Another game feature is shown in Figure 5. At the end of the game, players are requested to respond to questions about levels of satisfaction regarding the product idea generated by the players themselves, and to point out cards that were missing from the screen but necessary to complete the product idea. This information is crucial to answer this paper's first research question.

We hypothesize that generating new product ideas (different from other ideas) are inferred by the unexpected combination resulting from presenting different products' components with different combinations of pieces. Moreover, unobserved data and information as well as tacit rules are indispensable to the enrichment of inferred ideas. This entails abductive reasoning by combining given pieces in addition to one's imagination and knowledge. It might occur in the context of actions in data marketplace as well. This hypothesis was evaluated by analyzing the playing logs of the developed web-based tool.

## 3.2 Experiments

Twenty undergraduate students from the University of Tokyo participated in the experiments; each student was given two out of the four proposed existing products, with their component pieces displayed on the screen. Students were assigned to groups of two or three member, and they finished the game within 30 min. The following two products were given at the start of the game. Words in angle brackets were written on the cards that are pieces of components given on the screen.

**A vending machine** consisting of (1) ways to use <pieces: time is money, check new drinks, sell drinks, exchange money, security, stock for disaster>, (2) function <pieces: maintain humidity, maintain control, calculation, refrigeration, lighting, air-conditioning, advertisement, card recognition>, and (3) material/infrastructure <pieces: safety, monitoring network, water bottles, light, electricity, logistics>

**A cram school** consisting of (1) ways to use <pieces: improve results, learning, career counseling, maintain motivation, extend community, practice exams>, (2) function <pieces: correction, stimulate competition, prepare questions, re-produce text in video, evaluation, knowledge of education>, and (3) material/infrastructure <pieces: text book, lounge, instructor, DVD, dormitory, inbox questions>.

Given that the above products are not relevant to the same industry, we cannot expect architectural compatibility with the new unexpected product ideas.

## 4 RESULTS

Throughout the experiments, all players initially utilized induction rather than deduction to address how to combine component pieces. Deduction here signifies a top-down approach entailing intentional efforts to select relevant cards by proposing hypotheses and rules at the beginning. Induction signifies a bottom-up approach using a quick-fix mentality, wherein cards are tentatively categorized without proposing hypotheses and rules, but by exploring the meaning of batches of cards as well as of those interrelationships. We found that using this type of bottom-up (all players) approach

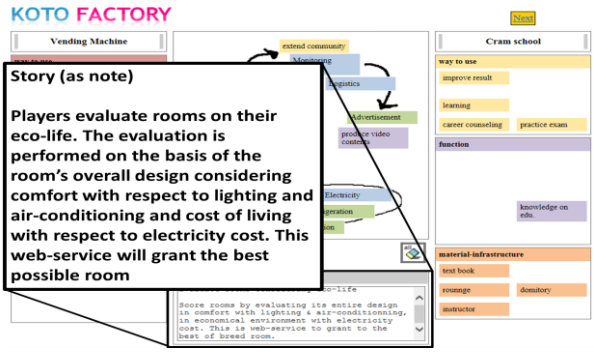


**Figure 3: Example of a result generated by the experiment**

to explore possible hypotheses and rules as well as those goals was able to reveal players' imagined pieces, which were not given on the screen.

Let us introduce a case study that highlights the abovementioned phenomenon, regarding the vending machine and cram school. The players were shown the factors considered during the experiment as depicted in Figure 3. The information was found at the bottom of the screen with the box title of "Story." The note for this case included that "players should evaluate rooms based on their eco-life. This evaluation should be performed on the basis of the room's overall design considering comfort with respect to lighting and air-conditioning as well as cost of living with respect to electricity cost. This web service will offer the best possible room."

Following the screen shown in Figure 3, players were asked to describe their generated ideas in more details using three questions: (1) *Who/what* is the customer/market? (2) *What* product idea is generated? (3) *Why* is the product competitive?

The respondents' feedback is as follows as shown in Figure 4.

*Who is requesting the product, and who evaluates the room?*: Anyone in the general public is a potential requester. Experts on "ecolonomic" design and the general public will evaluate the proposed room.

*What product idea is generated?*: One generated idea si to provide a web-service to compete ranking by scoring individual rooms in terms of ecolonomics.

*Why is the product competitive?*: Following recent ecolonomic trends, many people could be attracted to web services, resulting in sponsorship from various companies. Competition with score ranking and prize promotion may provide motivation to attract more customers.

At the end of the game, players gave constructive feedback about the web-based workplace to enable

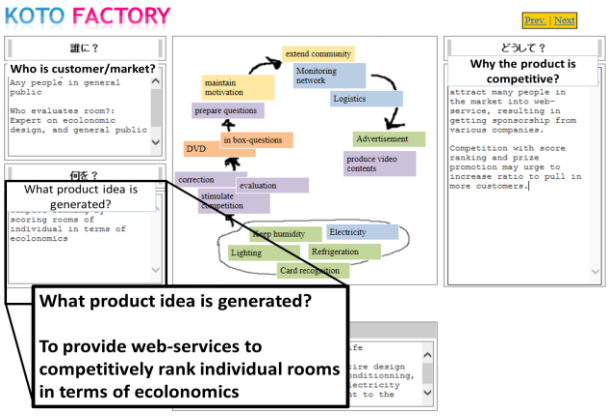


**Figure 4: A screen to explain the outcome in terms of who, what, and why**

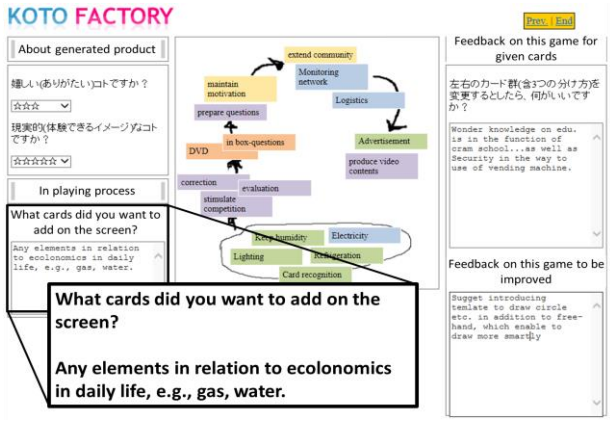


**Figure 5: Final screen image where several questions are posed**

further improvement of the application. In addition, players were asked to name the cards that they thought were critical for generating ideas and therefore should be added as depicted in Figure 5. In this case, these included "any element in relation to ecolonomics in daily life, e.g., gas and water."

## 5 New Model

In this section based on the result from the above work, we develop a new abductive reasoning model to express the outcome of Kotofactory by formalization. Then, we discuss about how Kotofactory would relate with Kotoframe. Finally, we explore clue to a data market place showing entire concept design process with both Kotofactory and Kotoframe.

### 5.1 Abductive Reasoning Model

First, the players' proposals will be analyzed. This experiment used a web service to create a competitive ranking of individual rooms in terms of ecolonomics.

This web service represents a higher-order concept of soft products consisting of the following contextual clauses where $P_n$ is defined as an appropriate context that is a constituent part of the entire story:

- Context $P_1$: Lighting and air-conditioning makes a room comfortable, and room design creates a good environment.
- Context $P_2$: By uploading photos of proposed rooms on the web, the general public can browse through them, leading to expectation of revenue from advertising.
- Context $P_3$: Objective evaluations can be made by experts and the general public, providing satisfactory confirmation of the results.
- Context $P_4$: ID cards enable us to collect data on electricity and appropriate data for a fair evaluation.

Within the above four contextual clauses, the concept of a web service emerges from the mixed given facts, mixed additional data, mixed hypotheses, and mixed rules. We believe that this complex structure represents not only a possible situation for providing a data marketplace but also the situation when we consider a company's marketing strategy. In this regard, an abductive reasoning model can be developed from the one mentioned in Section 2, i.e., in the event that an observed fact F is given, plausible hypothesis is generated where A[8] causes B[9] (B should be as long as A) in the context of the possible rule.

We will incorporate this hypothetical reasoning into the entire context by trial and error as appropriately as possible and subsequently determine the most plausible consolidation of a set of given facts, additional data, tacit memory and knowledge, hypotheses, rules and goals, thereby resulting in a change in consolidated hypothetical reasoning. Additional data here include (1) complementary data and information that is not given initially but is obtained by searching internal and external sources, and (2) tacit memory and knowledge that one develops during the task. By considering the meaning of these consolidations, product ideas are finally constructed.

The above process can be generalized and formalized, provided that given facts *F* are observed, and hypothesis *h* is generated to explain the observation such as $\{ P_1, P_2, \cdots, P_n \}$, where the relevant rule *r* is known. Let us call this initial process Rule 1, as shown Figure 1. Note that the new fact will

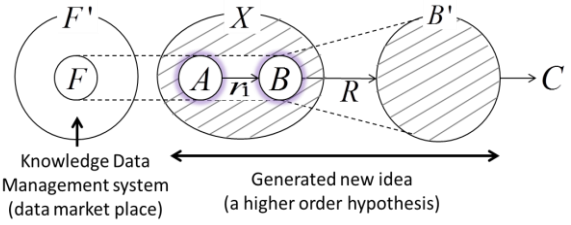


**Figure 6: Revised abductive reasoning model**

be added on the fact F initially given, depending on how one will search additional information from external sources such as web or books. Thus, the scope of *F* will become larger than the initial *F*, which is expressed with a symbol of *F'*. A proposed idea (a higher-order hypothesis) would be inferred involving a set of $P_i$ including respective hypothesis *h*, a set of rule *r*(Σr), and a set of given fact *F* and additional *facts*(Σ*F'*) , where Σ*F'* **U** {Σ*r*, Σ*h*} are satisfied by the incorporated rule *R*, as shown in Figure 6. The circle's size serves to illustrate the scope of context, i.e, A passed on to B according to Rule 1 and the given fact F, while X passed on to B' according to Rule R and the extended fact F'. Here, X contains combined different contexts.

In other words, once a fact *F* is given, an idea *X*, which incorporates sub-ideas where a set of *A* is passed on to a set of *B* in the context of respective rule *r*, implying *B*', can be developed by employing a knowledge data management system. This in turn could be one function of the proposed data marketplace, as well as abductive reasoning. The abduction here is a process of discovery to explain how *X* is passed on to *B*', as shown in the area drawn with diagonal lines in Figure 6. As shown in Figure 6, the dynamic process of human thought in considering of overall integrity could be broken down into several contextual clauses introducing formal logic, which is a rather static constraint among both rules and facts.

Moreover, the goal *C* could be shifted during the design processes depending on how additional $P_i$ are generated and how an entire set of $\sum P_i$ would be constructed in response to player's awareness of the goal. Therefore, the phenomenon here is not a typical abduction process that fixes the goal from the beginning. Thus, in a hypothetical context, collective rules and additional data are all incorporated on the basis of subsets and tacit knowledge, so as to identify the final goal *C*.

## 5.2 Formalizing the Outcome

Returning to the previous four contextual clauses of the case $\{ P_1, P_2, P_3, P_4 \}$, it could formally be described in the following manner:

[8] A means a well-formed formula such as *p*(*f*(a)) which contains predicate *p*, function *f*, invariable a ($\in$ D).
[9] Same formula as A, but different meaning.

**Context** $p_1$ **:** Lighting and air-conditioning make a room comfortable, and room design creates a good environment.

Set = { $r_1$ : Making a room comfortable
→ creating a good environment,
$r_2$ : Making a room comfortable
→ investing money}

Fact = {Lighting and air-conditioning
→ being comfortable}

*Hypothesis*: Lighting and air-conditioning as room design.

Consequently, *F*' U { $r_i$ , *h*} creates a good environment, which means that we take hypothesis *h* where "create a good environment" is satisfied with the rule $r_1$, the given Fact, and hypothesis *h*.

**Context** $p_2$ **:** By uploading photos of the proposed rooms on the web, the general public can browse through them, leading to the expectation of revenue from advertising.

Set = { $r_1$ : Many people browsing through photos of the proposed room on the web →
expectation of revenue from advertising,
$r_2$ : Many people browse through photos of the proposed room on the web →
wonder about the effect of advertising due to not knowing exactly how many people viewed it}

Fact = {Propose uploading photos of the room on the web → many people browse through them}

*Hypothesis*: Propose uploading photos of the room onto the web.

Consequently, *F*' U { $r_i$ , *h*} expects revenue from advertising, which means that we take hypothesis *h* where "expectation of revenue from advertising" is satisfied with Rule *r*1, the given Fact and hypothesis *h*.

**Context** $p_3$ **:** Objective evaluations can be made by experts and the general public, providing satisfactory confirmation of the results.

Set = { $r_1$ : Objective evaluation →
satisfactory result,
$r_2$ : Objective evaluation →
depending upon evaluators}

Fact = {Evaluation of rooms by experts and the general public → objective evaluation}

*Hypothesis*: Rooms should be evaluated by experts and the general public.

Consequently, a satisfactory result for *F*' U { $r_1$ , $r_2$ , *h*} depends on evaluators. This means that hypothesis *h* where "satisfactory result depending on evaluators" is satisfied with the rule $r_1$ , $r_2$ , the given Fact and hypothesis *h*.

**Context** $p_4$ **:** ID cards enable us to collect data on electricity along with other appropriate data for a fair evaluation.

Set = { $r_1$ : Appropriate data → fair evaluation,
$r_2$ : Appropriate data → depending on data}

F = {Using ID card → data such as electricity could be collected properly}

*Hypothesis*: Identifying individuals by using an ID card.

Consequently, *F*' U { $r_1$ , $r_2$ , *h*} yields a fair evaluation depending on data. This means that we take hypothesis *h* where "fair evaluation depending on data" is satisfied with the rule $r_1$ , $r_2$ , the given Fact and hypothesis *h*.

As an overall outcome, with a subset of hypotheses and rules such as $\sum p_i$ , the hypothesis *X* states that players evaluate rooms in terms of their eco-life, where the rule is that the evaluation is performed on the basis of the room's design considering 1) comfort with respect to lighting, 2) comfort with respect air conditioning, and 3) cost of living along with electricity cost. The final goal *C* is a web service to offer ranking by scoring individual rooms in terms of ecolonomics. These are in conformity with the revised abductive reasoning model in Figure 6.

The idea of a product comprises several contextual clauses sufficiently different to infer a higher-order context or service-offering scenario. Thus, the model corresponds to the first research question on how a business goal would be formulated using a hypothesis and rules.

## 5.3 Alignment with Kotoframe

As explained in Section 2, Kotoframe is a framework to support possible convergence from diversified ideas, and could function as a second phase of a data marketplace to address those ideas embodied with tangible forms. It reveals the conflict between market requirements and design specifications that should be resolved in the process of concept design, prior to manufacture, a proof of concept.

Kotoframe is described in the dotted-line boxes as shown in Figure 7. Kotoframe consists of three factors: performance, quality characteristic, and design specification. The factors in brackets, which are related to Kotofactory, correspond to performance, market requirement, and design specification.

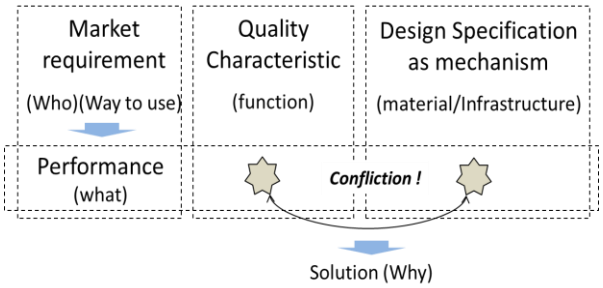


**Figure 7: Kotoframe drawn with dotted lines**

Performance is a parameter that customers expect as given before deciding to invest in/procure the product. The quality characteristic is a condition of the relevant market related to usage and the circumstance condition, such as maneuvering, time to use, temperature to be maintained, customer emotions, etc. The design specification is about the product's system architecture, which consists of dimension, weight, energy to drive, temperature, CPU, etc.

In the aforementioned case, the generated ideas should be considered in light of the three specified factors of Kotoframe, i.e., market requirement, quality characteristic, and design specification. An example of such ideas is given as follows, where the categories in brackets are the frame of Kotofactory, and the perspectives with italics are the frame of Kotoframe:

- How the eco-life is evaluated by experts and general public to score ranking is the *performance* perspective (way to use);
- How individual rooms could be viewed on a web-based environment considering the number of uploaded photos of the proposed room is the *quality characteristic* perspective (function);
- How the web-based architecture should be designed in terms of operational databases, storage, interface, and feeds from/to internal applications, are issues covered under the *design specification* perspective (infrastructure).

From the case study introduced in the previous section, a conflict could possibly arise between a user-friendly interface and a possibly huge number of uploaded photos. The former element is a quality characteristic in terms of viewing the individual rooms on the web, whereas the latter one is a design specification on how many photos of the rooms to be uploaded so that experts and the general public can view sufficiently and efficiently to evaluate rooms in a short period of time.

Once the possibility of such a conflict is identified, it can be solved with possible new technology or mechanism (such as an additional *function* for efficiently searching graphic data). Alternatively, the issue of how to design distributed computing with a service orientation could be considered, such as options involving a cloud application and/or virtualization for visitors to view huge numbers of uploaded photos (as an additional *infrastructure*) with lower cost to enable easier comparisons.

Figure 7 shows a conflict between parameters within Kotoframe, which is expected to address the issue. With reference to the revised abductive reasoning model shown in Figure 6, the shaded area is a delta to enlarge the context in consideration of *F*' instead of *F*, which is activated by the need to address the identified issue. Therefore, after generating a hypothesis, rules, and a goal through first step of using the data marketplace, the outcomes shall be formed by Kotoframe. However, Kotoframe might raise a conflict in the solution, and this means it is necessary to return to the first step of the data marketplace so as to further refine the previously generated ideas as would happen in a double helical model [9].

Therefore, Kotoframe supports efforts to find conflicts, knowledge of which is rather valuable input to consider when undertaking to implement the ideas derived from phase 1 of the data marketplace. This responds to the second research question: how the generated ideas will be embodied into tangible forms as concept design.

## 5.4 As a Clue to a Data Marketplace

In this section, we discuss how to relate Kotofactory and Kotoframe to each other and how these two tools should be considered in relation to the data marketplace. This study proposes that the data marketplace could consist of two phases: (1) generating new ideas from given data as explained with Kotofactory and (2) forming those ideas into embodied concept designs as mentioned in relation to Kotoframe.

The two phases are needed because players in the two phases are different in terms of knowledge and expertise, or even roles and responsibilities, in particular, in a company's in-house concept design process. For example, the company has different departments, such as product planning, product development, manufacturing, sales and marketing, where different experts are indispensable.

In this regard, Kotofactory is so straightforward to force participants to create their own hypothesis, rules, and goals by combining pieces of different products on the workspace, which includes nothing at the beginning. The effect of framed components has already been discussed in [5]. However, Kotofactory is able to record all actions, reproduce the user's process, and change the data/components/ products shown on the screen for various types of case studies. These

functions enable researchers to simulate how hypotheses, rules, and goals are generated, resulting in an ability to analyze possible abductive reasoning.

When considering a data marketplace, it is important to remember that Kotofactory is not designed for the data marketplace itself but as an empirical environment to analyze participants' cognitive processes. The data written on the card is not expected to be used in the data marketplace but rather empirically by a high-level agent for a stated limited purpose. Thus, the issue of whether the card data should be open/revealed or close/sanitized in terms of the data marketplace is beyond the scope of this study, despite the fact that this question is very important to consider when designing the data marketplace.

When it comes to Kotoframe, the following three factors should be discussed:

- The market requirement is clarified in line with *who* the customers are, *how* the product can be used, *what* and *what* product performance the customers expect.
- The quality characteristic is identified by grammatically breaking down the requirement into an adjective, adverb, noun, and verb. For example, the phrase "correct time to show it accurately" can be split to adjective (correct) and noun (time), which together mean correct time, while the adverb (accurately) and verb (show) together mean accurately show. The quality here can be identified from adjective and adverb, which might be also translated into a measurable or un-measurable indicator, while the function here can be identified from the noun and verb, as shown in Figure 8 [8]. The measurable adjective is, for example, "weighted" something, which can be identified in terms of a specific unit of measurement such as tons, kg, or meters, while the unmeasurable adjective is an element such as a "premium" design. For this unmeasurable element, the designer shall prepare some drawings to be evaluated by the requester or potential customer as a form of sensitivity analysis.
- The design specification needs feedback or input from persons having sufficient relevant product expertise to abstract a mechanism to get products to work.

Thus, the two steps are proposed on the basis of the same platform for consistency. We propose that the data marketplace contains two phases as shown in Figure 9, to form an overall concept design process, where both Kotofactory and Kotoframe are interlinked. The concept design idea shall be returned to Kotofactory for further refinement from Kotoframe to resolve conflict and/or to reflect the voice of customers.

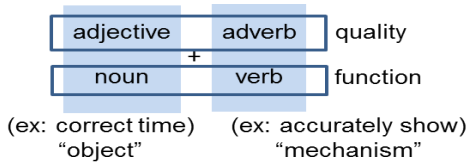


**Figure 8: Relation between quality and function with regard to QFD [8]**

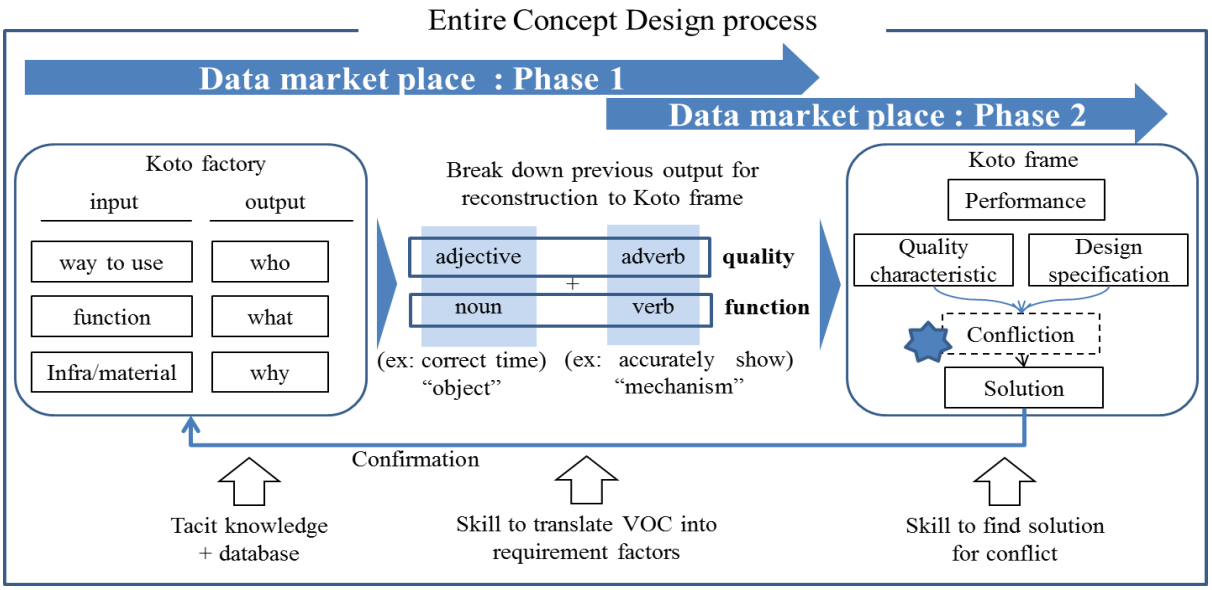


**Figure 9: Entire concept design process with Kotofactory and Kotoframe in relation to data marketplace**

Innovations in the past have shown that competitive strategies derived from analyses of objective data are not always successful [7]. Therefore, abductive reasoning with plausible logic is expected in the use not only with objective data (or facts) but also with latent data, enriched to improve the probability of innovative success. The knowledge used to innovate emerges from indirectly stimulating a person's mind to identify compatibility and other relationships between sets of data, as detailed in previous sections and in Figure 6.

We believe abductive inferences are stimulated by the limited given data set and components even as if the constraint stimulates creative ideas [1] with support from the data marketplace, which has two phases as depicted in Figure 9. We also believe an alignment of Kotofactory and Kotoframe can be considered as an input to the proposed design data marketplace, where players interact with the unstructured data provided to generate new ideas. These ideas are also expected to be further developed as hard or soft products through Kotoframe.

## 6 CONCLUSIONS

This paper introduces abductive reasoning model that produces hypothesis, rules, and goals, by referring to the case study utilizing an empirical environment called Kotofactory. As a blueprint for building a data marketplace, we have discussed about the entire concept design process associating Kotofactory with Kotoframe, i.e., from idea generation to addressing those ideas embodied with tangible forms through the use of dynamic quality function deployment.

Kotofactory and Kotoframe enable simple framework formation, which supports reconfiguration of ideas for use in a design data marketplace. More collective evaluation of case studies as well as designing the actual data marketplace, however, will be the subjects of future work.

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## AUTHOR BIOGRAPHIES

**Dr. Jun Nakamura** is a visiting professor at Research Center for Social and Industrial Management Systems, Kanazawa Institute of Technology. The areas of his research are innovation management and cognitive science.

**Masahiko Teramoto** is a Consultant of Electric Vehicle Technology. He worked in Nissan Motor Col., Ltd. as a senior engineer, and in Volvo Group Trucks Technology as a senior chief engineer. He is the specialist of Electric Vehicle Development.