DEALING WITH NON-TRADE-OFFS FOR FRUGAL DESIGN

Lecomte, Chloé; Blanco, Eric
Grenoble INP, France

Abstract

The frugal innovation approach takes place in developing countries to develop simple but essential products for low-income population. This approach asks for careful trade-offs to target a just-enough between cost reduction and essential value of the product.
In this paper, we aim at understanding how the essential value of a product is defined during early design phases, and how it guides the "just-enough" between affordability and performance. Our study of five frugal products in India shows three strategies that define differently the essential values and their associated just-enough: design by aggregation, design by extension, and design by focalization. Design by focalization seems to answer frugal design issues, as it isolates the essential value in order to reduce drastically the overall cost. The introduction of the concept of Non-Trade-Offs (NTO), meaning the non-negotiable elements that guide design choices, helps understanding how to separate this essential value from additional functionalities. Our study gives new directions for both practionners and researchers towards a design for essential value, in developing countries but also in westerns countries.

Keywords: Design practice, Early design phases, Frugal innovation, Essential value

Contact:
Dr. Chloé Lecomte
Grenoble INP
G-SCOP Laboratory
France
chloe.lecomte@grenoble-inp.fr

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

Developing countries are often characterized by scarce resources and infrastructures, political and institutional instability, and a huge concentration of highly vulnerable poor people. Designers (Schumacher, 1973), and now companies (Prahalad and Hart, 2002), are untrusted with a mission: designing products and services that meet essential needs, in order to fight against poverty. The frugal design approach takes a step ahead by proposing to simplify the product's features in order to extract its "essence of existence" while diminishing costs. This approach asks for careful trade-off to target a just-enough between cost reduction and essential value of the product.
In this paper, we aim at understanding how the essential value of a product is defined during early design phases, and how it guides the "just-enough" between affordability and performance.
The paper begins with a short review of the literature on frugal design as targeting the "just-enough" in both the product and the design process. We propose a new definition for frugal engineering to insist on its disruption with traditional approaches such as Target Costing or Value Analysis. In order to understand the design choices, we study the design practices of five frugal products developed for low-income people in India. Three design strategies are identified, each defining differently the essential value and the associated just-enough. By introducing a new concept, the Non-Trade-Off, we will discuss these design strategies as well as some perspectives to design frugal innovations.

2 FRUGAL DESIGN, ESSENTIAL VALUE, AND JUST-ENOUGH

2.1 Frugal design

The frugal design provides an engineering process that fulfils financial, material and institutional constraints in developing and emerging countries. Originally, the word 'frugal' means *"simple and plain and costing little"* (Oxford dictionary) or *"practicing economy, living without waste"* (Collins dictionary). From the literature review on this subject, we propose two axis to describe frugality: the frugal process (how to make a frugal product), and the frugal product (the characteristics of a frugal product).

2.1.1 A frugal process

At the beginning, the frugal design approach appeared to answer the growing demand of affordable but good quality products in emerging countries (Sehgal *et al.*, 2010). It was first an engineering process which aims to do "more with less for more" (Prahalad and Mashelkar, 2010), using a formalized, systematized and optimized method (Krishnan, 2010). It offers – theoretically – to reduce the cost of a final product by avoiding additional costs throughout the design: the product is cut into basic elements, then optimized by replacing the original materials by cheaper ones or minimizing the use of resources, and finally reassembled in the most economical way (Sehgal *et al.*, 2010; Tiwari and Herstatt, 2013).
Hence emerges the overriding idea that frugal innovation comes from an existing product (or concept) that can be transformed, using the less possible resources, or available locally, to model a product on local constraints (Meier-Comte, 2012). Somehow, this process seems to be closed to Target Costing approaches, where design choices are economically evaluated at the very beginning of design phases (Berlinger and Brimson, 1998; Kaplan and Atkinson, 1998). Several evaluation methods provide partial lighting to improve decision making in an objective of engaged cost-control in design, such as the DFM ('Design for Manufacturing') or DFA ('Design for Assembly')(Ansari and Bell, 1997; Ulrich and Eppinger, 2003). Their objective is to reduce cost by identifying, quantifying and eliminating additional costs in order to reduce alternatives in the problem definition (Gautier and Giard, 2000). In the example of the low-cost car Logan, Renault proposes a modern option to vehicles available in the market for an equivalent price (Jullien *et al.*, 2012). Designers and managers worked with engineering process inspired by the Target Costing approach, positioning suppliers as central in their innovation process, increasing component reuse and standardization, and pushing away the use of modularity and platforming (Jullien *et al.*, 2012; Midler, 2013). In echo, the Tata Nano is a textbook case in the frugal design literature, and shows great similitudes with the Logan case, despite their different success: early integration of suppliers, combination of existing resources and exploration of new architectures, and logic of mass-industrialization (Ray and Ray, 2011).

2.1.2 And a frugal product

Nowadays, this first vision of frugal design as a target costing approach is nuanced. Frugal innovation distinguishes itself from a cost-driven innovation (i.e. low-cost alternatives of existing products) as it offers new value propositions, meaning new functionalities (Zeschky *et al.*, 2014). Gradually, the vocabulary has evolved from a "how to do frugal" (the process) to a frugal proposal (the product). Here, the question of low-cost interrogates the concept of quality. The quest for the lowest cost (Rao, 2013) does not necessarily imply the degradation of the original product by using cheaper materials (Bound and Thornton, 2012; Zeschky *et al.*, 2011). Rather, the frugal design focuses on the most important specifications that increase value for the consumer (Basu *et al.*, 2013; Jain *et al.*, 2013). The goal is to redesign entirely the product to extract the essence of its existence without compromising on safety and comfort (Jain *et al.*, 2013; Van den waeyenberg and Hens, 2012).

In addition, frugal innovation considerate the whole product life cycle to reduce the overall cost of ownership. This idea is provided by the Indian concept “Jugaad” which illustrates a flexible and dynamic mindset that addresses immediate problems by making do and mend (Church and Elster, 2002; Radjou *et al.*, 2012; Seyfang and Smith, 2007). In other countries, these improvised arrangements for extending the product’s life are called "System D", bricolage, or other slang words showing the importance of the cost of ownership over time. The frugal engineering is a systematized (or industrialized) version of these “Jugaad” logics (Gupta, 2011; Jha and Krishnan, 2013; Krishnan, 2010), and this vision implies to guaranty the quality and the cost of a product in its local context.

2.2 A new definition of Frugal Design using the concepts of Just-Enough and Essential Value

To sum up the ideas above, the frugal engineering aims at reducing cost during design, production and use of a frugal product while enhancing its essential value, defined by its most important functional requirements (Basu *et al.*, 2013; Jain et al., 2013). The frugal approach is reminiscent of the Pareto rules that states that 20 percent of the effort, features, or investment often delivers 80 percent of the consumer value, which means “*you can drastically simplify a product or service in order to make it more accessible and still keep 80 percent of what users want—making it Good Enough*” (Capps, 2009). This minimalist approach – Good enough or Just-enough (Christensen *et al.*, 2006; Zeschky *et al.*, 2011) requires a meticulous negotiation between minimal cost and maximum value for the user.

The issue of cost and value is tackled by methods such as the Value Analysis. Instead of simply reducing costs, the Value analysis aims at eliminating unnecessary costs by analyzing the product functions and their associated values (Cerqueiro, 2011; Yannou, 1999).

Frugal design differs from Value Analysis as it implies the consideration of essential functions and values. Several authors propose to address frugal design by identifying first what is essential for low-income users in developing countries. Sehgal and his coauthors suggest a Design to Value, in contrast to a Design to Cost, which would "*involves a series of complex, varied, carefully thought-out decisions about which types of engines to use; which equipment should be standard; what safety add-ons to include; how parts and materials are engineered; and which designs are most attractive to the target customer base*" (p2)(Sehgal *et al.*, 2009).This proposition is close to Value-focused thinking, which proposes to identify first the key values, then alternatives to achieve them (Keeney, 1996).

From this discussion, we propose a new definition of frugal design as the research of a just-enough between the lowest cost possible for an essential value that satisfy a basic need. Therefore, frugal engineering focuses on simplifying the functions of a product to keep only the essential proposal that corresponds to the most important need and at the lowest cost possible. What is proposed here is a tacit equivalence between the satisfaction of the solution and the satisfaction of the main (essential) function. This proposal could be summarized by the equation (1):

$$\text{Frugal design} \Rightarrow \text{Max (Essential Value)} = \text{Max } \left(\frac{\text{Degree of adequacy of the product to essential needs}}{\text{Cost of the product}}\right) \quad (1)$$

A simplified notation would be (with F_{Es} for essential function)(equation 2):

$$\text{Frugal design} \Rightarrow \text{Max (Essential Value)} = \frac{\text{Max } (F_{Es})}{\text{Min (Cost)}} \quad (2)$$

This article will seek to understand the different trade-off and motivations to locate this just-enough by using case studies of product design for low-income population in India. Our objective is to characterize the approach used by designers to achieve the “just-enough”. Our hypothesis is that frugal

design looks for defining the essential value and therefore interrogates the meaning of the essential need.

3 FIVE CASE STUDIES

By taking a qualitative case studies approach (Eisenhardt, 1989; Yin, 2009), our goal is to describe the design strategies and needs' integration into design. Given the opportunities that had one of the co-authors when staying in India for a few months, we have selected five case studies that are representative of i) frugal product design for low-income population, ii) target an essential need in the sector of health and energy, iii) with a logic of low-cost, and iv) aiming at industrialized production. The five products are briefly described below:

- An **artificial knee-joint**, that answers to the needs of Indian amputees. First designed during an industrial engineering course in Stanford, the former students have now created the NGO ReMotion to launch the product. This knee-joint is called Jaipur knee according to the Jaipur organization that was at the beginning of the project;
- A low-cost **insulin pump** designed at Amrita University, in partnership with an engineering laboratory and a hospital;
- An **information system (IS)**, portative in the shape of a USB key for allowing rural patients to carry their personal health information in rural clinics. The IS is developed by AIMS hospital in Cochin, in partnership with the NGO Embrace the World and Amrita University;
- A **solar lamp**, called Mobiya, designed by the BIP BOP team of Schneider Electric for rural population without electricity;
- A **medical device**, designed by an Indian start-up, aiming at developing a new diagnosis device at very low cost. Because of confidentiality issues, we cannot use the technical data. We will refer to it as CMD for Confidential Medical Device.

These products are on different maturity levels. The IS is still in conceptual development, the insulin pump is in the manufacturing phase, whereas the Jaipur knee and the Mobiya lamp are already launched. All products are also driven by different structures, profit or non-profit, and from a start-up to a multinational company. The difference between these structures may potentially modify the objective (economic benefits or social impact). Finally, all cases are designed by Indian designers, except the Jaipur knee.

Eleven semi-directive interviews had been conducted with project managers (top manager and middle manager) and designers, as well as ten short interviews with users of the IS. While focusing on early design phases during the interviews, we tried to understand what the essential function (service function) was, what the associated technical functions were, and how the overall cost was reduced. This study in the India context, favored by the immersion of one co-authors during several days to several weeks depending on cases, helped to reveal the richness of real contexts and associated design practices (Eisenhardt, 1989). By emphasizing the design choices, the interviews' frame provided access to the design rationale, within the meaning of QOC (Questions Options and Criteria) (Kunz and Rittel, 1970). These case studies provide real opportunities to access rare data and revealing of particular situations (Yin, 2009).

The thirteen hours of interviews (numerated from 1 to 10 – see appendix) have been transcribed to remain faithful to used expressions and vocabulary. The interviews were restituted to the concerned team to be validated. In this article, some of the results are presented to show different approaches to define the essential value of a product and to target the just-enough.

4 DIFFERENT FRUGAL DESIGN STRATEGIES

The analysis of the interviews shows different methods to collect the users' needs and to translate them into functional requirements. Cost and value are evaluated through the main steps of the product life cycle (manufacturing, use, maintenance), which reveals various frugal strategies with dynamic and temporal considerations. To our questions "what is the just-enough" and "how is it defined", we cannot provide a unique answer. We propose here three different strategies, based on the five case studies: design by aggregation, design by extension, and design by focalization.

4.1 Design by aggregation

The Mobiya lamp and the Jaipur knee seem to follow the same design logic. For example, here is how a designer explains the different functions that provide the solar lamp:

> *"This is a new product we are launching this month, a portable lamp, with three different positions, and you can charge it in the solar panel, and you can charge your mobile. This is for putting the mobile when charging. We are also giving the solar panel and the charging cables. And the buttons you can see them during the night, it is photoluminescent, so you can see in the night where the lamp is.(…) People needed portability, this is a customer value. And you can place it in the bottle; you can use it as you want (…). You can drop the lamp, it doesn't break. This is the most brighten position; it can last 6 to 7 hours. You can use it for a safety lamp during night also. It is only the time difference. You save power. That's why we are giving different position."* [4]

From the main function (to light) follows a multitude of technical functions (portability, autonomy, durability) as well as additional functions (mobile charging, adaptation to multisurfaces,…) that ask for more technology to realize them (solar panel, LED, electrical cable, adaptors…).

In the same way, the Jaipur knee-joint is described as highly performant with a high range of motion for a stable gait and a natural swing, durable thanks to high strength polymers and stainless steel components, water resistant, light weight, noise dampening and adjustable to all artificial legs.

These two products are both highly performant with a low cost: on the one hand a lamp for $40 (same price of the solar market, but at a better quality), and a knee-joint for $80, compared to existing solutions that cost more than $500. Therefore the price remains still dissuasive for very poor people, and the two structures have chosen to make the product affordable by innovating on the associated business model (humanitarian market, microfinancing and microloans).

They also have in common a large panel of functionalities and characteristics that offer a multitude of options for a variety of uses. The consumer values are defined by functional requirements (amplitude of knee movement for a stable gait, autonomy of the solar system to provide light), but also by non-functional requirements, such as comfort (of walk) or portability (for outside activities).

These products seem to propose a set of non-hierarchized values, in terms of importance and essentiality, which aims to answer to all needs and issues at the same time. The arbitration between essential and superfluous values proposed by the frugal theory seems to be difficult to realize in practice: the identification (and isolation) of the essential value is not easy to apply by the design team as they may lack representation of the users in their integrity. The product is then resulting from the aggregation of all perceived needs, translated into essential functions (F_{Es}) and additional functions (F_{Ad}). This design by aggregation can be summarized by the equation (3):

$$\text{Frugal design by aggregation} \Rightarrow \text{Max (Essential Value)} = \frac{\text{Max } (F_{Es}+F_{Ad})}{\text{Min (Cost)}} \quad (3)$$

The answer to customer's needs is represented by the sum of existing functions (derived from the functions of competitive products on the market), and added features, and it is difficult to discern where begins the superfluous and where stops the essentiality as they are intertwined. The result is a technological solution that tries to answer to several user profiles and several uses by aggregating multi-values. In these cases, frugal design has only one disruptive axis: the minimization of cost engendered by the realization of all functions. In this sense, design engineering seems to be comparable to target costing approaches.

This strategy of aggregation is typically used to meet the needs of an heterogeneous population (Garvin, 1984). It makes sense in a context of international market, where a unique product can be mass-industrialized and matches to multiples needs in multiple contexts. The product value is then maintained throughout its life cycle through the creation of an entire ecosystem (services, production platform, and training), so that the product can perform the same it has been designed.

Alonso-Rasgado and coauthors examine these forms of products they call "Total Care Product" (Alonso-Rasgado *et al.*, 2004). These combined solutions can meet safety and quality specifications in every context, which means a global and standardized product transferable in other markets. For

example, Schneider Electric prolongs the product's life and values over space and time with maintenance, distribution and training services.

4.2 Design by extension

In the case of the IS, the global client-server architecture is kept, as well as the main functions of the software such as patient accounting, profile recording, health database, and the relationship between different subsystems (reception, monitoring, prescription…). In order to reduce development costs, the new proposition of an information system for rural areas is an extension of the existing platform with a new service: the externalization of the database with a USB storage to be kept by the patient.
Frugal design is here also using the existing platform, like the design by aggregation that uses existing manufacturing platforms. However the studied case shows the stabilization of existing value (the original IS) on which is inserted new functions that aim to specifically answer to the needs of low income (rural) populations. The frugal design is here a design by extension, exploiting the existing value to provide new essential service to the poor (equation 4).

$$\text{Frugal design by extension} \Rightarrow \text{Max (Essential Value)} = \text{Existing value} + \text{Max}\left(\frac{F_{Es}}{\text{Cost}}\right) \quad (4)$$

This design by extension entails a deep consideration of the new target population and their context of use. Our interviews with users and practitioners in the hospital illustrate the plurality of practices and regulation mechanisms that take place during the use of the IS. In the hospital, users prioritize important information among others depending on the objective and the task. When the IS does not answer the needs or the emergency of the situation, the actors regulate their own activities using other type of supports (phone to share essential information, written notes...). In the case of the new extended system in rural areas, the relationship between the patient and the doctor is isolated from other stakeholders of the network (pharmacy, health network, insurance…), which could cause other forms of regulations when IS failure. The extension of the existing IS in another context implies a better reliability of the new functions to avoid such situations: far from being a simple technology transfer from one context to another one, design by extension has to take into account the adaptation of the extended values to local contexts.
The immateriality of new technologies for information and communication (NTIC) authorizes this extension of functionalities without adding more development cost. The fixed costs of the existing product and its development are amortized, the existing value is reused, and new costs are only concentrated on the new functions implementation - in the case of the rural IS, the functions are materialized in a technological product (USB key). Examples of design by extension can also be found in the literature of NTIC innovation for poor people (see for example the Hystra report (Hystra, 2011), with particular references to the use of mobile phone to provide new services (financial, agriculture, coordination…).

4.3 Design by focalization

The last two cases – insulin pump and CMD – show another strategy to target the essential value:

> *"When you locate the problem, make sure you solve it. Rather than you go to the best solution at the beginning and it is really costly, go to the level where you can still identify chunks of big problems located, then you figure out what to do about it."*[8]

The two products aim at solving health diagnostic and healing with a more affordable – but still performant - method. For the insulin pump, the strategy was to simplify existing devices too *« sophisticated »* [7] in a simpler interface, with new functions that did not exist in other products. The frugal innovation is concentrated in a technological core that carries the essential value of the system: the reliability of insulin injection, and the design team focused their effort on the design of the pump itself and its functioning (microcontroller and software). The CMD follows the same logic of focusing on information reliability. This separation between core functions and additional ones is explained by the CMD's designer:

> *"The specifications are increased for core components, not for the secondary components. So if you see frugal methods or whatever we talk about, we talked a lot about cutting down the cost, but I would prefer to say that we use the best of the core functionalities, then what we can do about cost"* [8].

For the CMD and the insulin pump, cost and performance are combined by "*first identify the highest prices, make a way to reach it with the highest specifications, and then come back to a lower price*" [8] in order to transform a social issue into an engineering problem. Here frugal design is related to the research of an essential technological proposition that embeds on (or several) essential functions and that are uncoupled from other functionalities (equation 5).

$$\text{Frugal design by focalization} \Rightarrow \text{Max (Essential Value)} = \text{Max} \left(\frac{F_{Es}}{Cost}\right) + \left(\frac{F_{Ad}}{Cost}\right) \quad (5)$$

This model has a strong logic of reuse and remanufacturing as it uses locally manufactured products and components. In the case of the insulin pump for example, the insulin vial (the reservoir was designed to accept all forms of available vials from the Indian pharmacies), the catheter and needles are the same components as other insulin pumps, and the battery is a standard one available in all Indian stores. The product modularity and its embeddeness in local markets, as well as an appropriate product-service system, help maintaining its long term use and maintenance in different contexts.
The two products also have in common a progressive evolution of additional functions. The design teams are already imagining new features or other components to add to the products for targeting new consumers. For example, the insulin pump only applies to type-2 diabetic treatment that requires a continuous injection of insulin. The design team is now considering a new glucometer system with associated band, cheaper, more efficient and more stable for calculating the glucose blood level. This new product would be connected to a wireless insulin pump for automatic calculation of doses to be injected, following the European systems.

5 HOW TO ISOLATE ESSENTIAL VALUE? DISCUSSING TRADE-OFFS (AND NON-TRADE-OFFS) DURING FRUGAL DESIGN

5.1 Several just-enough for several essential values

This first part of analysis reveals several ways of achieving the just-enough depending on the product, the objective, and the resources. Compromises between low-cost and an essential value proposition can be made at different levels: during design (functional specifications), during the manufacturing choices, and during product use. These descriptions have quickly exposed other elements that interrogated the concept of essential needs beyond a functional approach. For example, what is performant or durable for low-income users? What is the brand value? Comfort, cosmetic, reliable… so much criteria that also play an important role for defining value (Rasoulifar *et al.*, 2014).
Designs by extension and by focalization have in common the isolation of an essential value, separated from other functionalities. Contrastingly, the Jaipur knee-joint and Mobiya lamp illustrate the difficulty to drastically reduce cost, as well as simplify the product for extracting its essential value, as proposed by the frugal design literature. Indeed, the BIP BOP manager notes: *"To be honest, if you look at our product, I will not say it is a complete breakthrough innovation, that didn't exist at all. They are hundreds of competitors, but we are trying to come up with one new offer that is better and more affordable"* [2]. Consequently, their design strategy was to identify competitive features: "*the frugality is more because of functions. It is still value for money, but it is… we are not playing with the quality of the components, or the reliability of the components; it is purely featurely"* [3].
This brings an interesting view that refines the frugal proposition by taking into account "*what is possible, what is feasible, what is sustainable*" [8], keeping in mind *"the line not to cross"* [6].

5.2 Is everything compromised? A change of scope to consider Non-Trade-Offs during design

When asking about cost and essential value, products designers indicate that some trade-offs are not possible. For example for a manager in Schneider Electric:

> *"Once we eliminate the quality question, and that we know that Schneider will never go below that line, then… all our design strategy, in BIP BOP or other technical department, is : how to design products that have the Schneider quality, that satisfy the market, and that have a low cost" [*6]

The same idea is stated by the designer of the Jaipur knee-joint, where the *"actual technical specifications mirror the international specifications"* [1]. The just-enough of frugal design seems not

to be driven here by the essential value, but is limited by a set of elements on which trade-offs are difficult to make. Therefore, we propose the concept of Non-Trade-Offs (NTO) that represent all non-negotiable dimensions that guide design choices. The NTO gather all non-debatable elements, tied to the organization, its past and objectives, and also linked to the definition of the product value.
The three design strategies that we have highlighted – aggregation, extension and focalization – result from NTO management during design. The use of existing production platforms, the choice of traditional suppliers, and the rigorous follow-up of the internal quality process are Non-Trade-Offs that the design team has to deal with to obtain a frugal product. These quality requirements make the separation between essential functions and additional one hard to make, as they form a whole functional bloc hardly negotiable. Cost can then only be reduced on material and manufacturing process. In the case of the IS, NTO are linked to the existing software; the business rules of computer engineers and designers are also NTO that guide the new functionalities development. NTO are also applicable in the insulin pump and CMD, and are concentrated on the essential value in order to make it reliable and performant. Other functionalities are left to the existing network (users and suppliers) which decides the product's faith.

5.3 Use of NTO to « break the rules » and isolate essential value

How to innovate while considering NTO? NTO on the (frugal) product implies NTO on manufacturing process to keep the expected quality, which considerably reduces the flexibility to innovate. For example, quality requirements demarcate a non-crossing line, defined by internal rules and processes.
However quality and product value have to be distinguished. Garvin (1984) states that these two concepts are often combined, and that "*the result is a hybrid — "affordable excellence" — that lacks well-defined limits and is difficult to apply in practice*" (p4). In action, the product value asks for the consumer arbitrage that confers – or not – a certain quality. In return, the product quality involves a subjective view of value.
From our study, quality is defined after a set of internal requirements, as shown in the example of Schneider Electric, or external requirements (e.g. ISO standards for the Jaipur knee-joint). These norms and standards are essential to ensure the patient safety (crucial in the area of health), and allow to harmonize global industry. In return, they sometimes hide a real reflection on the needs of users. Design by aggregation, for instance, reveals that taking multiple requirements into account implies a struggle to identify the essential value of the product.
As the CMD designer expresses: "*The standards are constructed by a reason; researchers are not exposed to these reasons"* [8]. By following strictly the quality standards in order to consider the users safety, designers are paradoxically getting away from users' needs. Therefore frugal innovation can mean to get rid of these standards and question the norms, in order to isolate the essential value from requirements. Clarifying implicit NTO may be a first step to leverage these blockages and think "out of the box". By formulating the non-negotiable elements, the design could further discuss the question of quality – thus value – and its implication for end users.
The type of structure should be considered to evaluate possible leeway. A small enterprise or a NGO has a flexible organization to play on the absence of procedures in order to get closer to users' needs (although small structures also have other constraints, such as the adequacy to international standards to be able to sell on an international market). In the case of a global enterprise such as Schneider Electric that manages more than 150 000 employees, its worldwide reputation and its brand image rely on a performant organization and process system. However these large corporations have to renegotiate their internal rules and standards to take into account consumer needs more strenuously. The Logan story shows that cost could be drastically reduced by breaking the Renault rules, which was only possible by outsourcing part of the R&D engineering team to Fiat who was able to overcome the Renault logic. These findings are also met in the design field: the creation of something (radically) new requires "*freedom, space, organizational and institutional as well as procedural freedom and the support of the organization to actually break through the boundaries of the established knowledge*" (p171)(Leifer and Steinert, 2012).
The BIP BOP design team of Schneider Electric made the first move towards a paradigm change by positioning itself as an autonomous structure, by adopting a more flexible organizational process, and by using a more agile logic to project management. Their approach favors the capitalization of new experiences in different developing contexts, and new teaching lessons on appropriate design.

6 CONCLUSION

The objective of this paper is to explore the concept of frugal design, still little developed in the literature. We have defined frugal design as the research of a just-enough between the lowest cost possible for an essential value that satisfy a basic need for low-income population in developing countries. The question we tried to answer was: what is this just-enough and how is it defined during design?

The study of five frugal products and the associated design choices shows three different strategies to target the just-enough, meaning different ways to define the essential value: design by aggregation, design by extension, and design by focalization. These three strategies may not be exhaustive of all possible frugal design strategies, but our study reveals the variety of approaches when dealing with designing for low-income people, as well as the multiplicity of possible just-enough.

Design by focalization seems to answer frugal design issues, as it isolates the essential value, upon a core technological proposition, in order to reduce drastically the overall cost. The introduction of the concept of Non-Trade-Offs (NTO), meaning the non-negotiable elements that guide design choices, helps understanding how to separate this essential value from additional functionalities. Here, we propose a new way to enhance frugal innovation by clarifying the NTO in order to escape from internal and external requirements and get closer to the final users' needs. Our study gives important directions for both practionners and researchers towards a better appropriate design for a contended life, in developing countries but also in westerns countries.

ACKNOWLEDGEMENT

Funding for this project was provided by a grant from la Région Rhône-Alpes, France. The authors would also like to thank all interviewees and partners of this research.

BIBLIOGRAPHY

Alonso-Rasgado, T., Thompson, G., and Elfström, B.-O. (2004) The design of functional (total care) products. Journal of Engineering Design, Vol. 15, No. 6, pp. 515–540.

Ansari, S. L., Bell, J., and The CAM-I Target Cost Core Group. (1997) Target Costing: The Next Frontier in Strategic Cost Management. New York: Mc Graw-Hill.

Hystra (2011) Leveraging Informaiton and Communication Technology for the Base Of the Pyramid - Innovative business models in education, health, agriculture and financial services.

Basu, R. R., Banerjee, P. M., and Sweeny, E. G. (2013) Frugal Innovation - Core competencies to address global sustainability. Journal of Managment for Global Sustainability, Vol. 2, pp. 63–82.

Berlinger, C., and Brimson, J. A. (1998) Cost management for today's advanced manufacturing, The CAM.I. conception design. Boston: Harvard Business School Press.

Bound, K., and Thornton, I. (2012) Our frugal future: lessons learn from India's innovators. Nesta Report. London.

Capps, R. (2009) The Good Enough Revolution : When Cheap and Simple Is Just Fine. Strategy + Business, pp. 1–5.

Cerqueiro, J. (2011) A proposal to incorporate the Value Analysis/Value Engineering techniques into PLM system, International conference on Innovative Methods in Product Design. Venice, Italy.

Christensen, C. M., Baumann, H., Ruggles, R., and Sadtler, T. M. (2006) Disruptive innovation for social change. Harvard Business Review, Vol. 84, No. 12, pp. 94–101.

Church, C., and Elster, J. (2002) Thinking locally , acting Lessons for national policy from work on local sustainability. New York: Joseph Rowntree Foundation.

Eisenhardt, K. M. (1989) Building theories from case study research. Academy of Management Review, Vol. 14, No. 4, pp. 532–550.

Garvin, D. (1984). What does "product quality" really mean. Sloan Management Review, Vol. 1, No. 1, pp. 1–20.

Gautier, F., and Giard, V. (2000). Vers une meilleure maîtrise des coûts engagés sur le cycle de vie, lors de la conception de produits nouveaux. IAE working paper No. 2000.01.

Gupta, A. (2011). Empathetic innovations for sustainable communities: heuristics for extremely affordable innovations. West meets East: what we can learn about innovating in the 21st century, 71st Annual Meeting of Academy of Management, August 14-16, USA.

Jain, K., Mukundan, R., and Gupta, D. (2013) Mapping innovations in the disruptive innovation realm in India. In Li, P. P. (Ed.), Disruptive Innovation in Chinese and Indian Businesses), New York: Routledge, Taylor & Francis, pp. 85–106.

Jha, S. K., and Krishnan, R. T. (2013) Local innovation: The key to globalisation. IIMB Management Review, Vol. 25, No. 4, pp. 249–256.
Jullien, B., Lung, Y., and Midler, C. (2012) L'épopée Logan. Paris: Dunod.
Kaplan, R., and Atkinson, A. (1998) Advanced management accounting, Upper Saddle River, New Jersey: Prentice Hall.
Keeney, R. (1996) Value-focused thinking: Identifying decision opportunities and creating alternatives. European Journal of Operational Research, Vol. 92, No. 3, pp 537-549.
Krishnan, R. T. (2010) From Jugaad to Systematic Innovation: The challenge for India, Bangalore: The Utpreraka Foundation, pp. 56–66.
Kunz, W., and Rittel, H. (1970) Issues as elements of information systems. Working paper No. 131, Institute of Urban and Regional Development, University of California, Berkeley.
Leifer, L. J., and Steinert, M. (2012) Dancing with ambiguity : Causality behavior, design thinking , and triple-loop-learning, Information Knoweldge Systems Management, Vol. 10, pp. 151–173.
Meier-Comte, E. (2012) Knowledge Transfer and Innovation for a Western Multinational Company in Chinese and Indian Technology Clusters. Identification of local and firm's knowledge transfer mechanisms to develop successful innovations. Rainer Hampp Verlag.
Midler, C. (2013) Implementing a Low-End Disruption Strategy Through Multiproject Lineage Management: The Logan Case. Project Management Journal, Vol. 44, No. 5, pp. 24-35.
Prahalad, C. K., and Hart, S. L. (2002) The Fortune at the Bottom of the Pyramid. Strategy + Business, Vol. 26, pp. 1–14.
Prahalad, C. K., and Mashelkar, R. M. (2010) Innovation's Holy Grail. Harvard Business Review, July.
Radjou, N., Prabhu, J., Ahuja, S., and Roberts, K. (2012) Jugaad innovation, a frugal and flexible approach to innovation for the 21th century, San Francisco: Jossey-Bass.
Rao, B. C. (2013). How disruptive is frugal? Technology in Society, Vol. 35, No. 1, pp. 65–73.
Rasoulifar, G., Eckert, C., and Prudhomme, G. (2014) Supporting communication between product designers and engieering designer in the design process of branded products: a comparison of three approaches. CoDesign: International Journal of CoCreation in Design and the Art, Vol. 10, No. 2.
Ray, S., and Ray, K. P. (2011) Product innovation for the people's car in an emerging economy. Technovation, Vol. 31, No. 5-6, pp. 216–227.
Schumacher, E. F. (1973) Small is Beautiful: a study of economics as if people mattered. Blond & Briggs.
Sehgal, V., Dehoff, K., and Panneer, G. (2010) The Importance of Frugal Engineering. Strategy+Business.
Sehgal, V., Reppa, R., and Tominaga, K. (2009) Building Cars by Design. Strategy + Business.
Seyfang, G., and Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. Environmental Politics, Vol. 16, No. 4, pp. 584–603.
Tiwari, R., and Herstatt, C. (2013) "Too good" to succeed ? Why not just try "good enough"! Working paper No. 76, Vol. 49, Hambourg.
Ulrich, K. T., and Eppinger, S. D. (2003) Product Design and Development. In: Ulrich, K. T. and Eppinger, S. D., (Eds.), New York: McGraw-Hill Companies, Inc.
Van den waeyenberg, S., and Hens, L. (2012) Overcoming institutional distance: Expansion to base-of-the-pyramid markets. Journal of Business Research, Vol. 65, No. 12, pp. 1692–1699.
Yannou, B. (1999). Proposition de deux nouveaux outils d'aide à la décision en analyse de la valeur basées sur une définition opérationnelle de la valeur. La Valeur, Vol. 81, pp. 7–14.
Yin, R. (2009). Case Study Research. Design and Methods, Thousand Oaks: Sage Publications.
Zeschky, M., Widenmayer, B., and Gassmann, O. (2011) Frugal Innovation in Emerging Markets: the Case of Mettler Toledo. Research-Technology Management, Vol. 54, No. 4, pp. 38–45.
Zeschky, M., Winterhalter, S., and Gassmann, O. (2014) From Cost to Frugal and Reverse Innovation: Mapping the Field and Implications for Global Competitiveness. Research-Technology Management, Vol. 57, No. 4.

APPENDIX

List of interviews

[1] Designer (Jaipur knee) *60 min*	[3] Technical manager (Mobiya) *30 min*	[5] Business manager (Mobiya) *60 min*	[7] Designer (Insulin pump) *60 min*	[9] Doctor/technical designer (IS) *40 min*
[2] Top manager (Mobiya) *65 min*	[4] Operational manager (Mobiya) *90 min*	[6] Business manager (Mobiya) *45 min*	[8] Designer (CMD) *180 min*	[10] Hospital staff (IS) *150 min*