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Lessons learnt from designing PSS for Base of Pyramid

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Abstract

In literature, theoretical elaboration of PSS on the context of Base of Pyramid (BoP) is limited. To fill the gap, this paper discusses theoretical aspects of PSS for BoP markets. Based on literature review and a case study with renewable energy sector in rural areas in Bangladesh, the paper identified main conditions in designing a PSS for BoP markets (e.g. need of a deep understanding of customers), customer values for a PSS on BoP markets (e.g. income generating opportunities), and design characteristics particularly relevant to BoP markets (e.g. who and where of design).

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1. Introduction

Product/Service System (PSS) has been heralded as one of the most effective instruments for moving society towards a resource-efficient society [1], and has been provided in industry and researched in academia since 1990s [2, 3]. A lot of insights are available in literature, however, virtually all the practices and theories have been discussed and developed on the context of the matured economy in developed countries thus far.

With a broader perspective on the context of sustainability, there has been a global issue of north and south (e.g. [4]). In addition, the sizes of the Base of Pyramid (BoP) market are huge. Just as an example, the energy market of BoP is 351 billion US dollars (USD) in Asia, 31 billion USD in Latin America, 27 billion USD in Africa, and 25 billion USD in East Europe [5]. Insight about PSS in BoP markets on the other hand has been reported in a limited manner with only a few exceptions (e.g. [6-8]). Despite the huge market size of BoP, insight about PSS for BoP is lacking. This motivates the research reported on the paper. Yet, another motivation is to enhance the existing theoretical insights about PSS, e.g. to decrease risk of conceptual myopia and methodological problems, by increasing cross-contextual research, as is argued

relevant in the discipline of product innovation and management [9].

This paper aims at opening up and deepening discussion of theoretical aspects of PSS for BoP markets in this research community. Among others, PSS design will be focused. To do so, first, PSS literature is reviewed. Then, a case study of PSS design is conducted for BoP market in Bangladesh. The case is about electrification with an intelligent solution for rural energy services.

The rest of the paper consists of the following sections. Section 2 gives a brief review for PSS design for BoP markets. Sections 3 and 4 present the research method and results of the case study, respectively. Sections 5 and 6 discuss and conclude the paper, respectively.

2. PSS for BoP markets

2.1. BoP markets

BoP refers to the bottom segment of an economic pyramid formed when people around the globe are categorized according to their annual per capita income based on purchasing power parity in USD [10]. It constitutes a market of

the world's poorest people living on less than 3,000 USD/year in local purchasing power [11].

BoP markets extend across Africa, Asia, Eastern Europe, Latin America and the Caribbean, and South America. They are characterized by high growth rates both in terms of economic output and populations. Their growth rates even surpass those of the matured economies, i.e. ToP (Top of Pyramid) markets [12]. Despite these markets having an aggregate population of 4 billion and purchasing power of 5 trillion USD [11], they have social challenges such as lack of road networks [13], under-developed infrastructure [14], low incomes [13], lack of education [13, 15] and lack of banking services [16]. These challenges, however, do not represent a general picture of the whole BoP market, because some countries in the BoP have made tremendous progress in reducing these challenges as their calls for investments from multi-national companies have increased [15].

On the other hand, the BoP markets have unique advantages that can be leveraged, for instance, by investors such as vast market size and less competitive environments. Because multi-national companies are competing fiercely in the ToP markets, BoP markets could present possibilities of a strategic shift for these companies [15, 17]. Other advantages of the BoP markets include high growth rates [12, 15], opportunities for innovation and for cost saving [15, 17].

2.2. PSS in BoP markets

A PSS concept can be defined as “a marketable set of products and services capable of jointly fulfilling a user's needs” [3]. Furthermore, PSS focuses on customer needs so it constitutes a long-term relationship [18]. An example offered by Rolls-Royce under a contract termed “power-by-the-hour” involves gas turbine engines and related services and is paid for performance rather than for selling engines [19]. Instead of companies selling more products to maximize revenues, PSS approaches incentivise companies to minimize material consumption against a need and increase product reuse, remanufacturing, and recycling. Environmental and economic benefits of PSS are claimed in some practical cases [19-22]. Note that these are discussed based on ToP market conditions.

For the purpose of illustrating existing PSS in BoP markets, two examples are summarized briefly according to [7, 23]. The first one takes place in Rwanda [23] and Kenya [24], and is called Indigo solar project : This PSS provides poor households with access to electricity. The product provided to a PSS receiver is a personal solar electricity system (e.g. a solar panel). The PSS adopts a Pay-As-You-Go approach, where the households pay over small weekly installments through mobile phones. This leads to cleaner energy as environmental benefits and also leads to social benefits for the off-grid population.

According to [7], the other example takes place in Brazil, and the program is named ECOELCE. This program provides discounts in the energy bill of low-income consumers in exchange of solid waste that has a market value. The program involves different stakeholders such as recyclers, government agencies and private companies. The economic impact is to avoid non-payments and illegal connections, because the low-income customers will obtain a discount in their bills in return

of providing the solid waste. The social and environmental impacts include the increase of living conditions (due to the decrease of wastes improperly disposed on urban environment) and recycle.

As described above, PSS in BoP markets have different characteristics from those in ToP markets. This implies different sorts of challenges and opportunities for PSS design, serving as a basis for this paper.

3. Research methods and questions

The research was guided by three research questions (RQs). The methods adopted for answering the research questions is a combination of literature review and case study. These are presented and detailed below.

RQ1: What are conditions of the BoP as the target market that should be considered in designing a PSS?

The paper studies the conditions that are characteristic to the BoP markets to be taken into consideration for PSS design. Knowing that there has been extensive research on PSS design in ToP markets and several examples of its implementation to point to, the authors are aware of risks that PSS design solutions according to insights from ToP markets can with uttermost certainty not work if they are merely copied and pasted into the BoP markets. Against this reasoning, it is imperative to study these conditions in order to tailor PSS design solutions to suit the BoP markets context.

The method for answering the first research question is mainly literature review on the characteristics of the BoP markets. Keywords were used for the search in order to narrow down the research, such as base of pyramid, developing countries, emerging countries and rural areas.

RQ2: What are customer values of the BoP as the target market that should be considered in designing a PSS?

Answers derived from RQ1 will partly aid in answering RQ2. However, RQ2 investigates customer values in particular, because they are a core for design in general. As shown by the examples in Section 2.2, the customer values are assumed to be different from those in ToP. RQ2 is mainly answered based on the case study but complemented by literature review.

RQ3: What are design characteristics of a PSS peculiar to the BoP market?

Answers derived from RQ1 will partly aid in answering also RQ3. RQ3 seeks characteristics for design that are peculiar to the BoP due to the focus of the paper. RQ3 is answered mainly by analyzing the results from the case study.

4. Case study

4.1. Case description

This case company is named ME SOLshare and operating in rural areas of Bangladesh. According to the International Energy Agency [25], almost 40% of the population in Bangladesh has no access to the national electricity grid. In 1997, the Infrastructure Development Company Limited (IDCOL) was established by the Bangladeshi Government in

order to improve medium to high-scale renewable energy infrastructures. After that, Partner Organizations (POs) of IDCOL started distributing Solar-Home-Systems (SHSs) in the rural areas of Bangladesh to mitigate this lack of access to electricity.

ME SOLshare provides the POs with their core product, named SOLbox. It is a small box that mainly functions as a SHS charge controller. It enables people owning both SHS and SOLbox to share electricity to those who own only a SOLbox. In this way, limitation of electricity storage of SHSs and electricity access is mitigated. ME SOLshare wanted to establish a means of improving their existing similar offering by adopting a PSS design method in their design process.

4.2. Study procedure

The case study was carried at the headquarter of the case company in Berlin in early 2016. The authors conducted action research by collecting necessary data from the company employees. The PSS design method adopted is SPIPS [26]. Motivations of choosing SPIPS include the fact that it has been verified with regard to its effectiveness for PSS design on ToP markets [26], and it is formulated in a flexible manner so that it was deemed to be applicable to BoP markets as well. The data collection method used for the case study was to carry out interviews, surveys and to review company documents.

4.3. Results

The first four steps of SPIPS have been applied to derive levels of importance and satisfaction of identified customer values. Table 1 shows the level of importance and satisfaction of the identified customer values in average of answers from ten experienced experts in the ME SOLshare. The thresholds between high and low for importance and satisfaction were both set to be 4.0, the median of 1 and 7. The numbers shown in bold in Table 1 mean that they are higher than the threshold, i.e. higher importance or lower satisfaction.

Table 1. Importance (I) and satisfaction (S) of the customer value in average (the scale is between 1, lowest, and 7, highest for importance. That for satisfaction is between 1, highest, and 7, lowest).

Customer value	I	S
1. Access to electricity	6.2	3.7
2. Easiness to understand use of the system	6.1	3.2
3. Reliable access to electricity	5.9	4.7
4. Affordable price of electricity	5.8	4.0
5. Access to more power	5.1	4.5
6. Income generation opportunities	4.7	4.5
7. CAYG (cash in as you go payment system) offered	4.4	4.1
8. Mobile banking services offered	3.7	3.3
9. Customizable tariff offered	3.4	3.3
10. Access to low direct current/voltage	2.8	2.9
11. Access to real time database and connectivity	2.1	2.4
12. Availability of data transmission	2.0	2.4
13. Ability to send data through internet	1.9	2.6

One interesting observation is the “access to electricity” received the highest level of importance, which has been the main intention of the offering’s vision. In addition, “income generation opportunities”, “CAYG (cash in as you go payment system) offered” and “Mobile banking services offered” are characteristic to BoP markets.

Then, relevant characteristics for designing the PSS were identified. Characteristics of the product, i.e. the SOLbox were as follows.

- Life time
- Capacity of electricity
- Data logging and data storage capabilities
- Retrofit capability
- Capability to display electricity real time
- Capability to interconnect multiple SHS

Those of the service were as below.

- Frequency of field visits
- Time of response for a repair
- Efficiency of implementation of the retrofitting
- Quality of the provided information
- Quantity of the provided information

This step is followed by identifying relevant components for designing the PSS. Components of the product were as follows.

- Battery
- Central communication system
- Net-meter
- Charge controller
- Bi-directional DC-DC- convertor
- Human machine interface

Those of the service were as below.

- Installation/maintenance trainers
- Maintenance/repair technicians of ME SOLshare
- Maintenance/repair technicians of POs
- Technicians in local villages
- SMS Mass messenger
- Service manual
- Service toolkit
- Sales officers

Based on a calculation procedure having built up on Quality Function Deployment [27, 28], which is a part of SPIPS, relative importance were derived. The top five important characteristics were: Capability to interconnect multiple SHS, Capacity of electricity, Quality of the provided information, Capability to display electricity real time, and Life time in a descending order. The top five important components were: SMS mass messenger, Service toolkit, Service manual, Battery, and Human machine interface, in a descending order.

These important items facilitated the designers to derive promising improvement options as listed in Table 2. Other sources of information used as reasons for this selection are cost for ME SOLshare coupled with the influenced customer values plotted in the satisfaction/importance matrix [29] using the data in Table 1. Further, description of end users’ activities with Customer Activity Cycle (CAC) [18] performed within SPIPS helped designers with create the options.

Table 2. Selection of the improvement options

Improvement option	Reason for selection
Offering battery saving service	<ul style="list-style-type: none"> • Low cost • Influencing CV1; High I / high S • Influencing CV3; High I / low S
Implementing direct communication between phone and SOLbox	<ul style="list-style-type: none"> • Low cost • Influencing CV2; High I / high S • Influencing CV8; Low I / high S
Introducing common informative messages, e.g. maintenance advice	<ul style="list-style-type: none"> • Low cost • Influencing CV3; High I / low S • Influencing CV1, CV2, CV11; High I / high S
Using Twitter for sharing information	<ul style="list-style-type: none"> • Low cost • Influencing CV1; High I / low S • Influencing CV1, CV2; High I / high S
Drilling easy instruction on the SOLbox for end users	<ul style="list-style-type: none"> • Low cost • Influencing CV5, CV6; High I / low S • Influencing CV2; High I / high S

Note: CV denotes Customer value. CVs' numbers refer to those in Table 1. I and S mean importance and satisfaction, respectively.

5. Discussion

Using the case study and literature review, the answers to the research questions are answered in the proceeding subheadings.

5.1. RQ1 - conditions of the BoP

One of the most outstanding condition of the BoP markets that should be put into consideration in designing PSS is that end customers are low-income consumers due to the definition of BoP. This was addressed explicitly also by the case study as shown in a quite important customer value, income generation opportunities. This condition of BoP leads to a challenge of affordability. A large share of the BoP populations does not earn a sizable income and in most cases the incomes are irregular [13]. This is further discussed in Sections 5.2 and 5.3.

The next condition is the low labour costs in the BoP, in relation to the low incomes. Companies designing PSS for the BoP could take advantage of the low labour costs. This is also further discussed in Section 5.3.

The third condition is barriers to information about end users, i.e. market intelligence. Unlike the ToP markets where there is readily available data or knowledge about people's way of life and culture, BoP markets rarely provide such data in the public domain [10, 13]. In this regard, companies devising PSS for such markets need to own deep understanding of the end users including their way of life. In the case study, such barriers were observed and overcome to some extent by staff with long experience in staying in the target areas in Bangladesh.

The fourth condition is a practical need of local partnerships from the ToP provider's standpoint, because of a variety of huge differences between BoP and ToP such as lack of education [15] and under-developed infrastructure [13]. Such differences discovered in the case study included the need of training the customers for using the products and difficulty of rural outreaches for physical delivery of the products. Local organizations are useful in obtaining market intelligence [17].

Companies that have been successful in the BoP have, in many cases, partnered with relevant local stakeholders [17]. These partnerships have a lot of merits such as easy marketing and faster distribution [17]. In the case study, the POs were adopted to support ME SOLshare.

The fifth condition is people's lower trust on brand and commercial companies. Neuwirth [13] points out that due to lack of access to information and excessive amounts of fake and poor quality brands offered in BoP, customers have less trust in new companies entering BoP. Customers in BoP markets don't usually trust companies including sellers [10].

The need for market price regulation was identified as the last condition. From the case study, it was discovered that basing the price of electricity on the principle of demand and supply (as deregulated markets in ToP) was not seen fit to serve the purpose. During times of high demand, the price of electricity would skyrocket and disadvantage consumers and during times of low demand the price would fall down and equally disadvantage the electricity producer ("prosumer" in this case).

5.2. RQ2 - customer values of the BoP

The customer values identified in the case study that are supported by other offerings in the BoP [7, 13, 17, 30, 31] are categorized into four groups and explained below.

Income generating opportunities: This is supported by the first condition in Section 5.1. This is reported as a relevant issue in another case as well; according to [17], Hewlett-Packard, in piloting a new solar-powered digital camera and printer setup, provided local Indian women with income generating activities (through photographing) in Kuppam, India.

Affordability of offerings: This is also supported by the first condition in Section 5.1. This is reported as a relevant issue in other cases as well; according to Unilever, the size of their products is packaged small enough to be affordable in the target market [31]. According to [17], DuPont, in partnership with various organizations in Colombia including Ministry of Agriculture and bank, helped farmers afford to purchase the inputs needed for the season to maximize their yields by providing forward payment for their harvests.

Meeting basic needs and functions: The cases reported in literature [7, 17, 30] coupled with the case study had customer values that had a strong connection to basic needs of and functions for consumers living in BoP. These include access to safe drinking water, nutrition, housing, as well as sanitation [17], access to electricity in the case study, access to energy [7], and payment [30].

User friendliness of products/services: As indicated by the fourth condition in Section 5.1, people in BoP have less chances to get education. Therefore, user friendliness is valued for end users to learn how a product/service works. As an example in [10], PRODEM FFP, a financial services company in Bolivia introduced finger print recognition in addition to colour coded touch screens and voice interaction in three local languages to their ATMs. This was in a bid to allow even illiterate customers access high quality financial services. BoP customers do not need to memorise their 9-digit passwords due to this innovation.

5.3. RQ3 - design characteristics for the BoP

Because BoP consumers have low incomes, they are reluctant to regularly renew products except when they reach their physical end of life. Therefore, **durability of products** is important to these consumers. Assurance of a longer lifetime of a product has a big potential to attract more customers. Durability as a design characteristic also has an implication of prioritized maintenance/repair and monitoring of products as additional service on the design of PSS.

Affordability can be attained by either decreasing total lifecycle costs of PSS or making payments more even along timeline (by e.g. provision of micro-finance to consumers). The low cost's implication on design of PSS in the BoP is that offerings should leverage local resources in order to keep production costs relatively low based on the **low labour costs** in BoP. In addition, to provide maintenance/repair service in a cheap way is employing women specially trained to do simple troubleshooting and maintenance tasks like the Indian case study [31, 32] based on the fact that women do not migrate to the cities once they acquire vocational skills [10]. In the case study as well, the use of local technicians was identified as one of the improvement alternatives. Flat payment can be realized by service of e.g. micro-finance institutions to facilitate loans to consumers. Further concerning affordability, there is a high risk of consumers defaulting on payments. Therefore, PSS offerings should take **payment methods** into full consideration as well. For instance, they could leverage the ever-growing revolution of mobile money transactions to enable consumers save money in their accounts and make easy payments via mobile phones.

The third and fourth conditions of BoP (as raised in Section 5.1), i.e. barriers to information about end users and a practical need of local partnerships from the ToP provider's standpoint, have implications on **who and where of designing**. Design for BoP needs to pay attention to these. Designing makes use of information about end users, and the accuracy of the information needs to be maintained in order to produce effective design solutions. To do so in designing, involving end users [33] physically at the target markets or collaborating with local partners with information about end users will be effective. Design methods enabling to describe relevant information about end users will support designers effectively, such as SPIPS building upon CAC to describe customers' activities. It should be emphasized that this issue has not been thoroughly debated in literature.

As implication of income generating opportunities as customer value on PSS design for the BoP, PSS benefits from incorporating services that enable involved consumers to generate **extra incomes** and/or products that produce something economically valuable.

As implication of the user friendliness of product/service on design, the product/service should be designed **easy to use**. In addition, it is effective to add **simple instructions** to products that can be easily understood by someone with the lowest of education. Alternatively, PSS offerings could partner **with local entrepreneurs** as a service provider to educate consumers on how to make optimal use of the product/service.

Design of offerings should take into account the importance of **customer's confidence** on the offering, in order to increase their loyalty and avoid customer's mistrust. There is a way to influence them and thereby e.g. convince them of the quality

(e.g. efficiency) of the offering – through villagers or members of the neighbourhood called “McGyver”. This character owns higher technical know-how in the community, and other members of the community respect them and appreciate their judgment. The process would be first to identify this person, then to provide him/her with a free offering so that they can try it and finally share their experience with the other potential customers. It is a way to access the market and increase the trustworthiness of the offering. In direct terms, this can be implemented as part of marketing but has implication on design such as need of incorporating McGyvers' preferences.

Last not but least, offerings for BoP should be designed to meet potential **customers' basic needs** and functions, because this is a customer value in BoP.

6. Conclusion and future works

6.1 Conclusion

The paper sought to answer how to support Product/Service System design for the BoP markets. PSS design was carried out as a case study with an offering for the BoP markets in an action research manner, providing a practical account in literature. Literature review was also performed on BoP. The key findings consist in the answers to each research question, providing some insights for theoretical aspects of PSS for BoP.

First, the main conditions to consider when designing a PSS for the BoP markets are: low incomes, low labour costs, barriers to information about end users, a practical need of local partnerships, low trusts on companies, and need of price regulation.

Second, BoP customer values reported frequently are: meeting basic needs and functions, affordability of offerings, user friendliness of products/services, and income generating opportunities.

Third, the design characteristics for the BoP markets include need to implement and maintain the product durability through the lifecycle, need to decrease the total lifecycle costs and/or each payment, possibility to make use of inexpensive labour in the target markets for services such as maintenance and repair, high potential of user involvement and collaboration with local partners, and need of user friendliness of offerings. In particular, who and where of designing was raised as an important issue that lacks discussion in literature.

6.2 Future works

In order to provide even greater understanding of PSS design both for BoP and in general, the authors recommend further studies as follows. First, comparison of the case study reported in this paper with other PSS design cases for ToP is expected to highlight differences and similarities between the two. To do so, a PSS design case for ToP with the same design method as in the presented case study [26] will be useful. In addition, different PSS designing for BoP in terms of sectors, settings, cultures, economic systems etc. will be useful to enrich the knowledge about PSS design. Interesting focus could be how challenges in various BoP markets of the globe that normally limit investments can be overcome by PSS design.

Abbreviations

BoP: Base of Pyramid
 CAC: Customer Activity Cycle
 CAYG: cash in as you go payment system
 IDCOL: Infrastructure Development Company Limited
 POs: Partner Organizations
 PSS: Product/Service System
 RQs: research questions
 SHSs: solar home systems
 ToP: Top of Pyramid
 USD: US dollars

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