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CONCEPTUAL/ THEORETICAL PAPER

Understanding the feasibility and value of grassroots innovation

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Abstract
Grassroots innovation (GRI) that meets the needs of people at the bottom of the pyramid is driven typically by economically disadvantaged people who find practical and creative solutions using indigenous knowledge to solve their localized problems. In this study, we propose a comprehensive framework to describe factors contributing to the feasibility and value of GRI in society. By employing a triangulation approach, we identify the drivers of GRI, develop and define GRI as a multidimensional construct, explain the outcomes, and suggest the moderating factors conducive to GRI success. We then discuss and develop research propositions on the various proposed relationships in the GRI framework. In addition to setting up a foundation for a future research stream based on GRI, this study provides implications for policymakers, mainstream firms, and co-operative societies/ non-profit organizations to realize the financial, environmental, and societal benefits from GRI.

Keywords Grassroots innovation · Social inclusion · Sustainability · Bottom of the pyramid

Introduction

The way innovative offerings are placed in markets embodies a distinctive contradiction, especially from the perspective of the bottom of the pyramid (BOP) market. The general focus of multinational corporations (MNCs) has been on conforming to the groups/segments qualified for the most sought-after term in the field of marketing, i.e., demand- a need and want backed up by the willingness and the ability to pay for the offering. The slice of the market with the greatest demand potential has always been a blue-eyed segment to marketers, but in the midst of addressing the "demand" of this highly profitable segment, firms, marketers, and academics have overlooked the first basic step of marketing, i.e., understanding the "needs" of customers, especially of those who fall in the realm of BOP. While MNCs put in effort to address the needs of resource-constrained BOP consumers with cost-effective innovations (such as frugal and reverse innovation) mostly with a mentality to "do well by doing good" (Agnihotri 2013), an estimated 4 to 5 billion consumers at the BOP remain largely left out from global demand markets (Prahalad 2012).

Now the question arises: is this oversight just a matter of viewing the BOP entirely from a demand perspective? Or is it a matter of the BOP's inability to pay for the products available in the mainstream markets? Are the marketers to be blamed for not understanding the exact needs of the BOP segment and failing to serve such customers well? If the latter is true, then we really need to assess marketers' efficiencies and abilities to evaluate need and demand, given their goal of serving every customer on the planet and creating a better world. The world cannot be better if 5 billion of the world's population falls within the base of the pyramid and are underserved.

While consumers at the BOP have low incomes averaging approximately US$2.00 per day, this market segment nonetheless offers a promising business potential due to its sheer size and related volume effects (Prahalad 2012; Tasavori et al. 2016). Assessing this market from only the demand perspective impairs a holistic understanding of the phenomenon and its undercurrents beyond the ability to pay. For example, it would be difficult to understand the need for Mitticool (a refrigerator made of clay), retailing for around $75–$80, versus other alternatives such as Chotu Kool, a low cost, battery-operated refrigerator specifically designed for BOP consumers, or "previously-owned" refrigerators from well-established brands retailing for approximately the same price. However, if we were to consider the constraints associated

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with the rural community, such as lack of consistent electrical power, small housing space, frequent relocation in search of livelihood, etc., the need for a clay refrigerator that is lightweight, low-cost, low-maintenance, and runs without electricity and batteries becomes easier to understand. Mitticool succeeds in understanding not just the needs of BOP consumers (keeping vegetables and fruits fresh and providing cool drinking water), but also life at the grassroots level, making it a better fit for the BOP markets over mainstream products.

A huge disparity exists between the products available from the mainstream market and the needs of the people from the grassroots[1] and/or BOP customer segment. How can this gap be bridged or fulfilled? One way to do so is through "Grassroots Innovation" (GRI), which refers to products emerging from innovations brought about by individuals, known as grassroots innovators, who are from the economically disadvantaged segment, are well-versed with their community's needs/problems and their resource constraints, and are intrinsically motivated to solve their community's problems via innovative solutions that combine local, contextual, and traditional knowledge.

Apart from bridging the considerable gap between demand and supply in the BOP market, GRIs are also relevant to a country's economy as well as to larger and multinational corporations, especially in the emerging markets. Euromonitor International (2019), based on the evaluation of the BOP in total number of and share of adults living on an annual disposable income below US$5000 (on the basis of purchasing power parity, or PPP) and a net wealth of less than US$10,000 (PPP), has identified the top five BOP markets—i.e., India, Nigeria, China, Indonesia, and South Africa. In such markets, the availability of the right set of products yields multiple benefits such as an increase in productivity, better health and hygiene, drudgery reduction, self-efficacy enhancement, fewer accidents, and greater environmental sustainability (Gupta 2016). The successful GRIs bring fortune back to the BOP community and generate new avenues of employment at the grassroots level, making community members feel empowered and self-dependent. Having greater productivity at the grassroots level is a great signifier of a balanced economy, especially in the emerging markets where agriculture typically contributes the most to that country's economy. In the emerging markets, where GRIs germinate in scarce environments lacking support, firms can take it upon themselves to learn about and understand GRI markets and their ecosystems while also providing constructive support to grassroots innovators.

There has been an array of work done on the issues pertaining to GRI (Gupta 2010b, 2012, 2016; Smith et al. 2014; Kumar and Bhaduri 2014; (Nair et al. 2012; Fressoli et al. 2014; De Keersmaecker et al. 2012; Gupta 2012). Gupta's contribution to the field of GRI (Gupta 2010b, 2012, 2016) has enhanced the knowledge on this topic and uplifted the lives of underserved communities. However, there has always been a predicament in defining the GRI. There is also a limited knowledge on how innovators-cum-entrepreneurs at the grassroots level can capitalize on this indigenous knowledge and creativity to transform ideas into tools for revenue generation and inclusive economic development (Nair et al. 2012). Currently there exists only a limited organized exploration into understanding GRI as a phenomenon in the literature especially in the domain of marketing. Therefore, in addition to providing a structure to the existing knowledge, this research conceptualizes and defines GRI as a multidimensional construct and proposes an organizing framework of antecedents, moderators, and outcomes of GRI. Through this framework this research discusses the factors critical to the feasibility of the GRI as well as the conditions under which the optimum outcome value can be attained. This is the first study to provide an integrated framework for GRI to better comprehend the GRI phenomenon in a holistic way. Table 1 outlines the contribution of this study when positioned against the relevant extant literature. This paper also discusses other BOP-focused innovation in brief and provides their distinction with GRI and hence provides the definitional clarity. In consort with providing implications to policymakers and firms, this study pave a foundation for future research streams on GRI.

The rest of this paper is divided into five sections. In the next section we build an understanding of GRIs by capturing insights from extant literature, field interviews, and marketplace evidence. Adapting this triangulation approach, the third section identifies and explains GRI as a multidimensional construct. Informed by insights from our triangulation study and the theories from extant literature, the fourth section presents the conceptual framework comprising the antecedents driving GRI, the consequences of GRI, and the moderators enhancing the relationship between the GRI and its various consequences. The concluding section discusses the specific implications of the study for the concerned stakeholders and the implications for future research.

Understanding GRI

Pertinent literature

GRI occasionally gets confounded with the myriad terms available in the literature related to bottom-up, community, and BOP-based innovation. To bring forward a clear understanding of GRI and to clearly distinguish it from other type of innovations, we follow the categorization at the grassroots level, for the grassroots, and from the

[1] This paper defines *grassroots* as an economically disadvantaged segment (mostly fall in BOP segment), coming from rural or nonurban areas.

Table 1 Grassroots innovations: select literature

Author	Market	Innovator	Type of study	Data collection	Discussion	Contribution
Smith et al. 2014	Emerging	Community	Descriptive	In depth interviews	Identified knowledge creation as an outcome of GRI and the challenges associated with the dissemination of GRI movements.	Defined knowledge creation by GRIs and their contribution to innovation policies
Kumar and Bhaduri 2014	Emerging	Individual	Exploratory	Informal interviews and observations	Making a distinction between Jugaad and GRI. Listed the key characteristics of GRI and their value creation.	Informal sector (GRI) innovations add value in the form of economic value, socio-psychological value, and knowledge value.
Nair et al. 2017	Emerging	Individual	Conceptual /narrative	Case study research	Innovator characteristics and the sources, triggers, impact and cost of GRIs	Understanding on GRIs and GRI innovators in emerging markets
Fressoli et al. 2014	Emerging	Individual and community	Exploratory	Case study research	The encounters of GRIs with mainstream institutions and how the encounter can lead to two new models of inclusive development, 1) insertion and 2) mobilization	The study suggested that it is important to be attentive to process-based approaches and not only outcome-based models.
De Keersmaecker et al. 2012	Emerging	Individual	Conceptual	Review of literature	The study investigated design drivers that assist successful scale-up of GRIs.	Three main drivers to scale up GRI- 1) local fit with market, 2) local fit with constrained resources and 3) social sustainable
Gupta 2012	Emerging	Individual	Conceptual	Marketplace Evidence	The study put forth the idea of knowledge rich yet economically poor people as providers of sustainable solutions in the form of GRI.	Extended the concept of GRI in emerging markets as opposed to developed markets. Linked GRI with existing models of innovation
This Study	Emerging	Individual	Conceptual	Triangulation Approach (Literature Review, Field Interviews, Marketplace Evidence)	Provides structure to the existing knowledge and develops understanding of how GRI spawns in the society and what outcome value it generates; the boundary conditions facilitating the GRI outcomes; and a foundation for launching future research streams based on GRI	Conceptualization of grassroots innovation (GRI) as a multidimensional construct. Developing a comprehensive framework which focuses on the antecedents, moderators and the outcomes of GRI Recommends implications for policymakers and firms for enhancing GRI in the society.

Table 2 Categorization of bottom of the pyramid innovations

Category	Type	Definition	Objective	Idea Generation / Innovator	Consumer (User)	Markets	Example
For the Grassroots	Reverse	"Innovations from low-income contexts can enter more wealthy markets, a major shift from the previous innovation paradigm." (Simula et al. 2015)	Cost cutting, solution orientated	Local Needs and Companies	Consumers from both emerging and developed markets	Emerging + Developed	GE Healthcare low cost ultrasound and electrocardiogram machine.
	Frugal	Development of simple and ecological products, process, service, and business models with low input of resources, low cost, and little environmental intervention (Gupta and Wang 2009)	Cost cutting, solution orientated	Companies	BOP consumers	Emerging + Developed	Tata motors when they made $2500 nano car
At the Grassroots	Community Innovation	"A type of user initiated innovation whereby the community itself is an essential element of the innovation" (Oost et al. 2009)	Addressing social challenges, community empowerment	Community as a whole	Community	Emerging + Developed	Microcredit, Self-help Groups, Community education
From the Grassroots	Grassroots Innovation	"innovation by economically poor but knowledge rich people who are disconnected from formal market ecosystems but are able to creatively deploy their indigenous skills and local knowledge" (Gupta 2010a, b)	create a product/ service fulfilling the need of consumers at BOP	User/ community person	People at grassroots (sometimes including innovator)	Emerging Markets	Mitti Cool
	Jugaad	Improvisational approach to solving one's own or others' problems in a creative way, at a low cost, in a short amount of time, and without serious taxonomy or discipline (Brem and Wolfram 2014)	Cost cutting, solution orientated	Users	inventor and the community	Emerging Markets	Using a motorcycle to drive a pump in the fields

grassroots (Gupta 2012), as discussed below. Table 2 provides the further clarification.

Innovations at the grassroots These innovations are carried out by NGOs, business corporations, government agencies, or individuals, either acting alone or in collaboration with local bodies, e.g., community innovation. Such innovation unfolds at the community level, engages a large populace in ownership of the movement (Van Oost et al. 2009), and employs the social capital of the whole community, which need not be limited to a specific geographical area. The key agenda behind such innovations is sustainability and improving the quality of life and well-being of the grassroots community (Seyfang and Smith 2007). These innovations may take the form of microcredit, the formation of self-help groups (SHGs), community education, etc. Open-source initiatives such as Linux OS, Wikipedia content, and Massive Open Online Courses (MOOC) also constitute examples of community innovation. The internet, having spawned global communities linked through web forums, social media platforms, and web pages, has been the harbinger of community innovation at an unprecedented scale. The motivating factor behind such large-scale collaborative endeavors is the need for solving shared technical problems, leading users to freely share their innovations without expecting private returns (Hippel and Krogh 2003).

Innovations for the grassroots Such innovations are conceived in tandem with the socio-economic development of the grassroots communities, particularly marginal communities, and are undertaken by either individuals or organizations, e.g., frugal innovation and reverse innovation. The concept of frugal innovations began with an agenda for increasing consumption in emerging markets by offering products and services that ranked high on affordability and accessibility, and were catered to meet the special needs of the lower socio-economic classes (Prahalad and Hart 2002; Zeschky et al. 2011; Weyrauch and Herstatt 2017). A case of such frugal innovation is the Tata Nano car developed by the Indian automobile giant Tata, which retailed at $2500, came outfitted with the basic quality and safety parameters expected from a low-end car, and was targeted at the lower socio-economic classes. An offshoot of frugal innovation was "reverse engineering," meaning innovation that developed under conditions of resource constraint and married local knowledge, talent and technologies, and new processes and business models (Govindarajan and Ramamurti 2011). Successful reverse engineering innovations are first developed in emerging markets and then offered to developed countries for adoption. For example, the highly functional imaging product Magneto Resonance [MR], Computed Tomography, developed by Siemens for Chinese Tier-II cities, was later offered to the United States as a backup secondary imaging machine (Agarwal and Brem 2012).

Innovations from the grassroots Innovations that come from the grassroots community without the employment of any outside formal help in order to address unmet needs or solve local problems are known as grassroots innovations (Kumar and Bhaduri 2014). Gupta (2010a, b) defined GRIs as innovations from the "knowledge rich but economically poor," that offer inclusive, sustainable, and affordable problem-solving techniques based on indigenous knowledge and skills, without formal sector backing. However, Smith et al. (2013) suggest a broader definition encompassing outside agencies and individuals such as technical and design experts who may engage in the project either through lending their expertise or providing the impetus for collaborative movements. Nair et al. (2012), while agreeing to a large extent with the definition given by Gupta (2010a, b), have further specified GRIs as being chiefly incremental in nature.

One of the earliest accounts of GRI in the marketing literature surprisingly occurs in an organizational context where grassroots employees come up with innovative ideas in a conducive organizational environment (Kanter 1983). Later it was discussed in a social context as a change agent for social development in the form of small-scale initiatives undertaken by either the public, private, or voluntary sectors in an urban setting at a small scale (Perlman 1990). The concept of GRI then broadened to embrace the rural setting by including the innovations developed in emerging markets by the marginal sections of the society, with an amalgamation of indigenous knowledge, creative thinking, and limited and locally available resources, at a cost affordable to the local populace (Gupta 1995). GRIs, in using locally sourced resources, traditional knowledge, and respect for ecological environment, contribute to the sustainability crusade (Pastakia 1996; Gupta 1998; Srinivas and Sutz 2008; Leach et al. 2012).

It is conceptualized that GRIs contribute to societal and environmental development by adding economic value, creating knowledge, and promoting the innovative spirit among grassroots communities (Gupta 2000; Appadurai 2000; Smith et al. 2013; Kumar and Bhaduri 2014). Exploring the human side of GRIs unearths certain characteristics of innovators, such as their personality, economic environment, moral beliefs, and social networks, all of which propel them to undertake potentially intimidating projects (Joshi et al. 2015). GRIs evolve when innovators are motivated either by a personal need or altruism, by their commitment to preserving traditional knowledge, by their participation in a hobby, and/or by economic benefits (Nair et al. 2012; Bhaduri and Kumar 2011). Furthermore, local fit with the market (affordability, acceptability, availability, and awareness), local fit with the constrained resources (investment, energy, materials, and infrastructure), and social sustainability are identified as design drivers influencing the successful scale-up of GRIs (De Keersmaecker et al. 2012). Because GRIs are designed to fulfill a local need, scaling them up may require large-scale adaptations to the product to suit a wider audience for which innovators may lack the funds and skills (De Keersmaecker et al. 2012; Smith et al. 2012). Also, many GRIs are not-for-profit projects and therefore are unable to demonstrate a steady revenue stream, making it difficult to obtain seed funding (Martin et al. 2015).

The modern economy, which drives the mass innovation movement, instills in people the aspiration, capacity, and the will to innovate. GRIs can be seen as an agent of economic change since they have the potential to generate prosperity for nations through employment generation (Phelps 2013), but they can also be perceived as a non-economic development agent, benefitting the society via knowledge production and the inclusion of marginalized communities (Smith et al. 2014; Bhaduri and Kumar 2011; Dutz 2007; Rao 2006). While previous studies on GRIs have focused on defining the concept in terms of its relevance to emerging markets and on the role of grassroots innovators in designing creative solutions for local problems, the current literature would benefit from a comprehensive conceptual model that explores the environment conducive to spawning GRIs, and that identifies relevant moderators and outcomes which have so far only been studied in isolation.

Field interviews

To understand the nuances related to the facilitation and capitalization of existing and potential GRIs, we conducted interviews with the relevant stakeholders in the society, including experts in the field of GRIs, the key government officials handling concerned departments, academic researchers, the heads and volunteers of relevant NGOs, grassroots innovators, and customers from the BOP segment. A total of 36 in-depth interviews, out of which 25 were face-to-face and 11 were telephonic, were conducted. Each interview lasted for approximately 45–60 min, the key points of the interview were recorded verbatim during the course of discussion, and the discourse was transcribed immediately after interviews were concluded. Additionally, a round-table discussion with the 20 CXO-level representatives from the mainstream business was conducted to understand the business's perceptions, insights, and intentions towards the BOP market; what they consider to be an appropriate and a viable way to address the market's needs; and their sentiments about innovations coming from the grassroots.

The interviews of all stakeholders were informative from the following perspectives. First, the relevance of GRIs could be understood in a holistic manner, which further helped us to explore relevant factors for building a conducive environment for GRI in the country. Second, talking to the firm's managers revealed their understanding about the BOP market, their interests and intentions to serve this market, and their

expectations and associated disappointments with the BOP markets. It was interesting to gauge their receptivity towards GRI, their readiness to collaborate and contribute, and their visualization of GRI as one of the ways to tap the BOP market. Past experience of the interviewees with the BOP marketplace and their linked prejudices provided us with improved clarity regarding the existing market ecosystem and the potholes which need to be filled. Third, these interviews provided an opportunity to look at this market optimistically, signaling potential for boundless outcomes. Fourth, the people at the grassroots level (consumers) provided a clearer picture of rural India and the changing consumption-related trends at the grassroots. Fifth, interviews with the innovators further offered insights on various challenges they deal with (such as non-acceptance of the idea by the community, funds scarcity, knowledge deficit on technology and raw material, etc.) and the support they seek when working to solve a given familial or communal problem via their designed products. Sixth, interviews with the heads and volunteers of non-profit organizations imparted to us the ground reality of executing these ideas and the corresponding changes in the existing belief system, especially at the BOP level. They also informed us about bottlenecks as well as the support innovators receive at the policy level.

Next, to build an understanding of the distinct attributes and characteristics of GRI products and to differentiate them from other types of BOP innovations, we collected direct evidence from the marketplace.

Marketplace evidence

The grassroots community abounds in examples of innovative ideas and movements, with the National Innovation Foundation (NIF) in India alone registering over 225,000 innovations.[2] While the NIF is committed to dissemination of GRIs for optimal impact, the reality is that not all GRIs are able to achieve the expected impact. When contemplating the impact and the diffusion of GRIs, it has been put forth that GRIs conform to the long tail model, the long nose model, the long tailoring models and the autopoesis model of innovation (Gupta 2012). A few of the GRIs under the long tail model are likely to spread among a large section of people whereas most other GRIs are likely to spread to only a small group of users. In the long nose model of innovation, GRIs may remain overlooked until the need for them is recognized by a large section of the society as the result of a pressing crisis. The long tailoring model of innovation offers high customization to users, while in the autopoesis model, innovations are embedded with high flexibility in design to suit different user groups. The choice of either model depends on the GRI's approach to inclusion and capability, although there exists common elements and attributes among these innovations.

The successful cases of GRI garner more attention from both the mainstream media and research bodies and are presented as successful stories for replication. However, each success story is accompanied by numerous letdown tales in the process. A total of 27 GRI products were studied, and a sample of a few such innovations is captured in Appendix. Here, we discuss two GRI cases in particular—the low-cost sanitary napkin making machine and the Mitticool refrigerator—which we feel succinctly cover the issues pertaining to the entire process and ecosystem of a typical GRI.

The first low-cost sanitary napkin innovation by Muruganantham started out as a personal project concerning the need of the innovator's wife and sister for menstrual hygiene. The available sanitary napkins in the market produced and marketed by large MNCs were too expensive to afford, while the cheaper traditional alternatives such as cloth and cotton were not hygienic or comfortable. Muruganantham recognized the need of low-cost sanitary napkins in his community by the fact that only one in ten women in his community were using sanitary napkins. His idea was met with backlash by many people in his community, including his own family. From the inception of the idea to raw material selection and its procurement, from prototype development to testing, from the generation of funds to the distribution of his product in the market—every aspect of his journey was beset by challenges. However, he ultimately managed to overcome them, producing a low-cost sanitary napkin by inventing a low-cost sanitary napkin–making machine dependent on the right set of raw material and a distribution strategy. This innovation later received the Presidential National Innovation Award, bringing his innovation into the limelight and enabling him to generate the necessary seed capital to set up a manufacturing unit to produce at a large scale. Driven by the goal of community empowerment, especially to uplift the lives of rural women, instead of by profit-seeking alone, he chose to disseminate his innovation through a network of franchisees, mostly women Self Help Groups (SHGs). By involving the community and the users of the product themselves, he managed to work around the taboo surrounding menstrual hygiene in India and gain acceptance for his product.

The second innovation, the Mitticool refrigerator, is another case of identifying needs at the BOP and delivering a product meeting those needs in an effective manner. The innovator Mansukhbhai Prajapati invented a clay refrigerator (based on the indigenous knowledge derived from an age-old earthen pot concept) that was not dependent on electricity and could be used to preserve food items and cool water. The innovator recognized the constraints at the grassroots and set about developing a product that was affordable, sustainable, and viable as a refrigerator. His prior experience and technical skills as a

[2] http://nif.org.in/aboutnif.

clay craftsman were key drivers in his success as an innovator. Each stage of his invention was met by fundraising challenges and lukewarm support. However, with the involvement of the Grassroots Innovation Augmentation Network (GIAN), India and the National Institute of Design (NID), India, this innovation was able to generate value both in terms of money and social good. He later set up a company (named Clay Creations), and with the right set of support from government and non-government entities and by adopting the right technology (e-commerce), his creation was able to reach not only the target BOP market, but also global customers in London, the United States, Singapore, and Africa.

The evidence from the marketplace emphasizes on the various unique attributes GRI products encompass. However, most of the GRIs are based on the "cradle to cradle" concept characterized by high sustainability and frugality (Gupta 2016). Marketplace evidences also indicates that GRIs not only satisfy the needs of the BOP segment, but exhibit the potential to attract the environmentally conscious segment of the mainstream markets as well.

By integrating the evidence from the marketplace with the academic literature and field interviews, we next conceptualize GRI as a multidimensional construct and propose a conceptual framework with relevant propositions.

Conceptualizing GRI

In order to conceptualize and define GRI as a construct, we adopted the thematic content analysis approach, according to which the qualitative data gathered from the triangulation study was thoroughly analyzed. Thematic content analysis, a "systematic coding and categorizing approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication" (Vaismoradi et al. 2013, pg no. 400), helped in extracting the attributes and dimensions pertaining to GRIs. For this purpose, a panel of six people was created, consisting of two PhD students, two practicing experts, and two professors. The verbatim scripts of the interviews and the evidences from the marketplace (i.e., the detailed information and specification of the studied GRIs) were shared with the panel members. They all independently examined and extracted the attributes and relevant themes, and then further organized them into meaningful dimensions/categories. Cohen's Kappa (Cohen 1968) was used to compute the inter-coder reliability, given its appropriateness for classifying non-quantitative data (Futrell 1995). The kappa coefficient was .90, an acceptable value for qualitative studies.

Based on the overall frequency of the attributes belonging to each of the themes and categories, the most important categories were identified. This qualitative analysis represented human interpretation of the dimensions that emerged from the information gathered from the conducted triangulation study, and no software package was used for analysis. Nevertheless, methodological rigor was upheld by the process of peer debriefing and consensual validation. The analysis procedures and findings were shared with academicians working in the area of qualitative research methods and/or in the area of innovation linked with BOP. They reviewed the methods, interpretations, and findings, and provided suggestions and feedback. The incorporation of their input further strengthened the results.

In the final phase of analysis, for the purpose of content analysis and face validity, the extracted attributes, themes, and dimensions were further shared with two assessors from the field of GRI and BOP consumer behavior. This process ascertained the face validity of the relevant dimensions insofar as they corresponded to the intended construct under this study (i.e., GRI) (Cook and Beckman 2006). Finally, in this process, six dimensions were recognized to conceptualize GRI, i.e., *Affordable Cost*, *Indigenous Knowledge*, *Informal Innovation, Sustainability*, *Local Fit*, and *Adaptability*, which are discussed as follows.

Affordable cost A market-based approach for BOP markets looks at not only delivering solutions for satisfying unmet needs but also at the market's willingness to pay (Hammond et al. 2007). Affordability for BOP markets defines the degree to which a product may be purchased under instances of limited cash availability and access to credit (Nakata and Weidner 2012). Though collectively the BOP is comprised of nearly US$5 trillion, individually most BOP consumers live below the poverty line. Thus, products need to be in accordance with the purchasing power of BOP consumers to ensure affordability (Chikweche and Fletcher 2012; Viswanathan and Sridharan 2012). Affordability is considered as one of the main appeals of GRIs and is used as a design driver in development (De Keersmaecker et al. 2012).

Indigenous knowledge This refers to a context-specific, locally acquired knowledge that is accumulated over time and unique to a given community, culture, or society (Sillitoe and Marzano 2009). Indigenous knowledge is mostly transmitted from one generation to another both orally and by practice (Subba Rao 2006). The World Intellectual Property Organization (WIPO) refers to it as traditional knowledge, or a pool of ideas, practices, skills, and technical expertise that is passed on from generation to generation within a community. Given their lack of resources and exposure to the new-fangled knowledge, members of grassroots communities tend to practice age-old learnt concepts and skills to meet their everyday requirements. Grassroots innovators within their local community have greater access to this vast resource knowledge pool passed on by their ancestors, their environment, and their

fellowmen, which in turn helps them to think differently from mainstream firms and design creative solutions that are faithful to the other dimensions of GRI, i.e., affordability, sustainability, and local fit. Hence, grassroots innovators are more receptive to integrating the indigenous knowledge for problem conceptualization, idea generation, and the design and production of their innovation to address a given local need (Gupta 2016; Nair et al. 2012). Therefore, GRI in particular enables the use of traditional knowledge to enhance the socio-economic development of the community.

Informal innovation GRIs are generally the result of fulfilling personal needs or of addressing community-specific problems, though they sometimes occur by accident. Moreover, grassroots innovators are usually disposed to receive support from their earned social capital (i.e., their family, friends, and community), lacking systematic support from any formal public or private entities. Grassroots innovators often lack higher education and/or technical training, with an average education amounting to 11 years. Cut off from the education system at an early age, they usually do not develop formal networks with universities, research and development institutions, technical training and skill development institutions, etc. that can provide support during the idea generation and development stages of the innovation (Nair et al. 2012). Also, at the initial stages, innovators themselves are not sure of the commercial potential of their innovation, and they are therefore unable to attract any formal partners or collaborators early on in the process. Moreover, because of the dispersed geographies, accessibility and reach seem to be a challenge for both the formal institutions and innovators. Thus, most of the GRIs form a part of the informal innovations landscape especially in developing markets (Kumar and Bhaduri 2014).

Local fit In the context of GRIs, local fit can be comprehended in terms of an innovation's fit with local resources, local needs, and the local socio-economic environment (De Keersmaecker et al. 2012). Innovative products display high acceptability predominance if they satisfy a local need and exhibit congruence with the local resources, materials, infrastructure, culture, and social norms (Singh et al. 2014; De Keersmaecker et al. 2012). Mainstream products that are not designed with such considerations in mind are likely to face market resistance and require customization to serve the BOP communities (Anderson and Markides 2007).

Sustainability GRIs are rooted in the pursuit of economic development in harmony with social and environmental values under the umbrella of sustainability, also defined as innovative bottom-up ideas for sustainable development (Seyfang and Smith 2007). While designing solutions for local markets, many MNCs may view sustainability in product and process as an imposition instead of a source of competitive advantage (Nidumolu et al. 2009). GRIs, on the other hand, are developed by local innovators who are in touch with their natural environment and who tend to use naturally available resources to design innovative solutions (Nair et al. 2012; Seyfang and Smith 2007). Most of the time, by incorporating locally sourced inputs, alternative energy sources, and frugal innovation practices, GRIs score high on sustainability (Pastakia 1998; Smith et al. 2013).

Adaptability Another important attribute of GRIs is their adaptability and flexibility (Smith et al. 2013). Adaptability means that a product can be easily changed to fulfill different functions or to enhance the product performance under different contexts (Li et al. 2008). For example, a bicycle GRI by Kamruddin[3] from India has multiple functionalities, serving as a mobile workstation for sharpening knives, as a drilling machine, and as a wood sawing machine. A single product serving multiple functions eliminates the need to own multiple products and further enhances the sustainability value of the innovation. GRIs sometimes have to incorporate auxiliary design changes to fulfill multiple requirements efficiently and economically, and hence exhibit the redesignability attribute (Kumar et al. 2013).

Amalgamated together, these dimensions define and characterize a GRI. Though a few other BOP focused innovations too possess some of these characteristics, all these dimensions should be in unison for an innovation to be called as a GRI. Nevertheless, each dimension will inevitably have a differential degree of measurement based on the required product specifications and category. Based on this conceptualization, in the next section, we define GRI and propose a conceptual framework along with relevant propositions.

Conceptual framework

Placing the six dimensions together, we define the GRI as "innovations originating from economically disadvantaged people, in an informal market ecosystem, creatively deploying their native skills and local knowledge to resolve their community problems in an affordable and sustainable way." Grassroots-invented products and services display the potential to contribute to the lives of individuals, especially at the BOP and on the macro level in the development of the community by generating new business activities (De Keersmaecker et al. 2012). Recognizing and understanding the various factors playing an important role in the entire process of bringing about GRIs would help policymakers, firms, and society at large to better understand not only their roles in encouraging more GRIs but also how the true potential of GRI can be realized. Hence, by extracting insights from

[3] http://nif.org.in/innovation/multi_purpose_bicycle/246.

the triangulation study, we propose a conceptual framework (Fig. 1) for GRI that demonstrates the antecedents, outcomes, and moderating variables between GRI and its outcomes. Additionally, we explain the expected relationship between the various proposed constructs in the framework and suggest several research propositions. Given the lack of a strong academic literature around GRI, the suggested propositions are mostly based on the insights drawn from the field interviews and marketplace evidence.

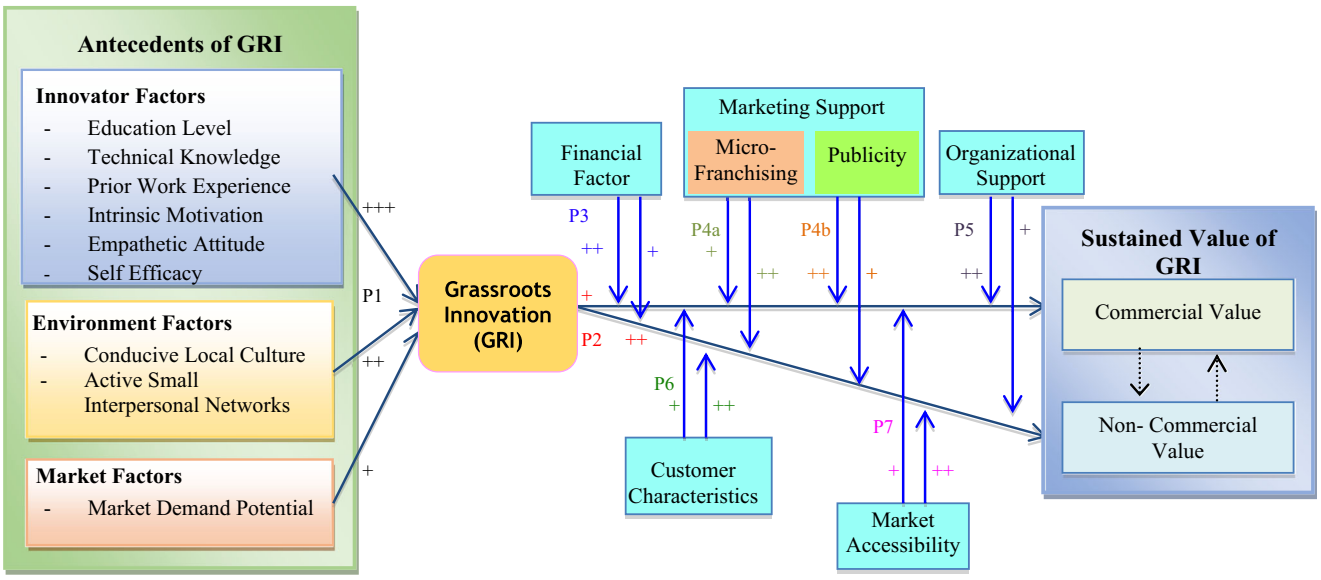
The framework first discusses the antecedents conducive to the growth of GRI in a given society, categorized as innovator factors, environment factors, and market factors. Innovator factors refer to the role of the innovator's education, technical skills, and prior work experience in bringing about the innovation. They further encompass the innovator's attitude towards life and fellow men, usually indicating a positive approach to problem solving; considerable empathy, sensitivity, collaboration, and a sense of belonging to a community; a high degree of belief in his/her ability to create and improvise in a challenging environment; and the motivation to work diligently and pursue his/her call. The environment factors emphasize the innovator's level of social capital, which makes him/her more aware of community problems and equips him/her with the collaborative and networking skills to exploit opportunities to venture out into the world of innovation. The market factors refer to the role of market demand in driving the idea of the GRI.

The outcomes of the GRI were categorized on the basis of the sustained value the given innovation would generate in the society, i.e., commercial and non-commercial value. The commercial value is characterized in economic terms, i.e., profitability, sales and revenue, etc., while the non-commercial value is related to the social and environmental benefits derived from an innovation, such as social inclusion, community empowerment, enhanced productivity, better health and hygiene, and waste reduction. Though a grassroots innovator may choose to make or not make his/her innovations commercially available (Gupta et al. 2003), there exists the potential in every GRI to generate the right set of sustained value.

Our framework lists the boundary conditions (moderators) which can boost the outcome effects of the GRI in order to derive its maximum potential. The five proposed moderating factors are: financial factors, marketing support, organizational support, customer characteristics, and market accessibility. For example, the financial factors such as availability of micro finance and low cost of innovation would enhance the expected outcome value of the given GRI, especially of the commercial value; likewise the conducive customer characteristics will support a higher degree of non-commercial value, with the given GRI being adopted by the community as a whole.

Antecedents to GRI

Innovator factors How are people from the weaker socio-economic communities, facing resource constraint challenges, able to come up with innovative ideas that are beneficial to the community as a whole? How are grassroots innovators different from non-innovators? The human capital theory advances answers to many of these questions by expanding an understanding of how innovators increase their human capital through education, technical know-how, work



Legend: +, ++, and +++ indicate increasing degree of relative effects.

Fig. 1 Conceptual framework for grassroots innovation

experience, motivation, and self-belief, and thereby become more productive individuals (Nafukho et al. 2004). It suggests that investment in human capital at an individual level provides a greater influence on innovative activities at a larger scale such as region and country (Popescu and Diaconu 2008; Dakhli and De Clercq 2004). This study looks at innovator characteristics facilitating GRI through the lens of the Human Capital Theory.

Education promotes human capital formation and subsequently acts as an engine to economic growth in varying degrees in the individual as well in the society as a whole (Paganetto and Phelps 2003). While having more years of formal education indicates a higher propensity for innovations, especially at the grassroots level, a substantially lower number of grassroots innovators exists within higher education; most of them lack formal education and tend to rely more on their experiential learning for innovative activities (Nair et al. 2012; Kumar and Bhaduri 2014). Field interviews and literature also unearthed that education is not a prerequisite of creativity, although it can help foster creative thinking by enabling a person's metacognitive abilities leading to creative consciousness and ideas (Fasko 2001).

Technical knowledge at the grassroots level refers to the skills and expertise of an innovator to accomplish a particular task related to the innovation, and drives investment in building the human capital of the innovators (Leiponen 2005; Paganetto and Phelps 2003). Innovators having formal technical knowledge in their respective areas of innovation equips them to tackle technical hitches during the course of innovation and bring frugality to their innovations. For example, Gurmeel Singh Dhonshi, with his skills as a mechanic and fabricator, innovated a mechanized 'Rapid Compost Aerator' using components such as the hydraulic jack and rotor blades.

Prior work experience provides experiential learning by offering firsthand understanding of the nuances of the domain, and helps in identifying and comprehending the magnitude of the latent and explicit problems and their consequences. Hence, it better equips an innovator to make use of the acquired tacit knowledge influencing his/her creative process (Csikszentmihalyi 1997; Mascitelli 2000). For example, MansukhBhai, the innovator of the Mitticool refrigerator, drew from his experience as a potter and clay craftsman to invent several clay-based innovations, such as a refrigerator, nonstick cookware, water coolers, etc., and to make them applicable to the given market needs.

Intrinsic motivation is the natural inclination of a person to work towards a task even in the absence of external rewards (Harter 1978). A study of human capital in an open innovation context, such as GRI—which is mostly filed under open licenses and involves voluntary contribution—indicates the dominant role of an innovator's intrinsic motivation in the process of innovation (Belenzon and Schankerman 2015). For example, Muruganantham, the innovator for low-cost sanitary napkins, struggled for numerous years at the operational level to seek social acceptance for his innovation idea. However, because of his deep-rooted motivation and persistence, he overcame all of his struggles to find a solution to the menstrual problems of lower socio-economic class women. Due to the resource constraint environment in which most GRIs are usually developed, it takes a high level of creativity and internal motivation to continue in the face of opposing forces.

Empathetic attitude according to social capital theory, makes the innovator more sensitive to social issues and inspires him/her to seek innovative solutions to the prevailing problems in the society (Camps and Marques 2014). Field interviews revealed that an empathetic attitude allows an innovator to uncover problems which may be overlooked by a non-innovator, even when he/she is not affected by such problems. V. Jayaprakash from Kerala, India, was inspired to innovate an eco-friendly cooking stove when he became aware of the plight of women who worked with traditional bio-mass cooking stoves, which emitted a lot of smoke and thus proved to be a health hazard. Empathy also allows an innovator to closely interact with society members, thereby gaining a deeper understanding of the pertaining issue (Freeman and Hawkins 2016). Gupta (2010a, b) suggests that an innovator's "samvedana," i.e., the ability to recognize and accept the problems of others as one's own, is a key characteristic of grassroots innovators.

Self-efficacy is a person's estimate of his/her own capabilities for successfully completing a task (Gist and Mitchell 1992). Though not all grassroots innovators may be viewed as social entrepreneurs, many do exhibit the entrepreneurial characteristic of self-efficacy by believing in their ability to see their innovative idea to fruition through an improved cognitive process and by displaying their commitment to solving the problem of their fellowmen (Masse and Dorst 2007).

Environment factors GRIs are closely embedded in the socio-environmental context of the region in which they originate. Hence, we chose the lens of social capital theory to obtain an understanding of the social relationships in a community that influence GRI development. Social capital facilitates the creation of intellectual capital (Nahapiet and Ghoshal 2000) and impacts innovative activities directly (Landry et al. 2002). It also increases the likelihood of innovation in the society (Zheng 2010; Dakhli and De Clercq 2004), thereby spurring GRI growth. The social capital theory is based on five broad dimensions including network-lateral associations, reciprocity expectation, trust, social norms, and collective efficacy (Lochner et al. 1999; Adler and Kwon 2002).

The first dimension, network-lateral associations, puts forth the social network of an innovator as a prominent factor contributing to an innovator's social capital. These social networks may be formal associations with government and non-government agencies, research and academic institutions, or financial institutions; or they may be informal, such as the innovators' social circle and community at large. Social networks make an innovator privy to inside information, connections, ideas, general assistance, and support (Burt 2000).

The second dimension, reciprocity expectation, refers to a person's moral expectation of being treated fairly in return for cooperation and favorable behavior (Gouldner 1960). Grassroots innovators often have to rely on social exchanges for assistance during ideation, product development, and capital generation and diffusion. Fair dealings during these exchanges help an innovator to receive favorable responses in successive exchanges.

The third dimension, trust, encourages idea sharing and information exchange at all stages without fear of misuse. Experts assert the opinion that in the case of community-led innovations, trust is even more important in establishing a common motive and cooperation and collaboration activities.

The fourth dimension, social norms, affect the human nature of belonging to a community as an individual and influence perceptions about social frames of references such as values, customs, stereotypes, and behavioral conventions (Sherif 1936). Moving against the tide of social norms can cause an innovator or entrepreneur to face difficulty during product acceptance; for example, Muruganantham was ostracized by his community for breaching the taboo subject of menstruation during his endeavor to produce low-cost sanitary napkins. Other than personal sanctions, he also found it challenging to convince volunteers to test his prototypes during the early stages of product development. Social norms also instill a sense of responsibility towards the environment among entrepreneurs (Meek et al. 2010). In the case of agricultural GRIs, the adherence to long-held beliefs about using organic methods makes it easier to gain acceptance among other farmers.[4]

The fifth dimension of personal and collective efficacy as opposed to self-efficacy relates to a social group's shared belief in its collective capabilities to accomplish a given task (Bandura 1998). High levels of collective efficacy may also increase the group's collective engagement, thus adding more determination and vigor to the task at hand and thereby affecting performance (Salanova et al. 2003).

Market factors Market factors, such as market demand, size, growth, and potential, propel the process and create a favorable environment for the development of sustainable GRIs. In general, economists extend two prominent theories of demand-pull and science-push to explain the role of market demand as a determinant of successful innovation, (Freeman 1979). The demand-pull theory identifies market potential and market growth as the determinants of innovative activities. The science-push theory proposes that changes in science and technology lead to innovations which are then adopted by the society at large. In the case of incremental innovations concerning small improvements over an existing product, market demand has a greater role as a determinant factor. However, for radical innovations, it is possible that market demand may not play as considerable a role because of the inability of customers to foresee an innovation far removed from their current awareness state or experiences (O'Connor 1998).

Knowledge of market factors such as size, growth, and potential assist the innovator in forecasting demand for the innovation, thereby providing impetus for development of the innovative idea (Mahajan et al. 1979; Acemoglu and Linn 2004). For example, Muruganantham, the innovator of low-cost sanitary pads, was sensitized to the fact that only about one-tenth of the women in his village used sanitary pads. His observations were further supported by a survey commissioned by the government of India that reported that only 12% of women across India used sanitary pads.[5] Thus, he could foresee the demand for his innovation and felt encouraged to pursue his low-cost sanitary napkins solution. However, considering the complexities of identifying and analyzing market trends, forecasting demand for GRIs remains something of a black box.

Innovator, environment, and market factors act together to provide a conducive environment for the occurrences of GRIs; however, a relative effect of these factors is expected to be experienced on the feasibility of GRI in the society. The motivation for an innovation to sprout is seen to come more consistently from innovator factors than from environment and market factors for two key reasons: first, most of the GRIs are an individual initiative taken up to solve his/her own and/or community problems. Employing his/her human capital, an innovator may continue to work on his/her goals with considerable perseverance in overcoming the odds available in his/her immediate environment (i.e., environmental factors).

As many GRIs arise by working against social norms and expectations, innovators are often challenged by a weak level of coordination and networking as opposed to the networking that exists among the stronger economic and cultural forces driving mainstream innovations (Gupta et al. 2003a, b). Owing to their foresighted outlook and strong internal persuasion, innovators generally do not seek the validation or

[4] http://nif.org.in/innovation/surjeet-basmati-1%2D%2Dhigh-yielding-and-salt-tolerant-paddy-variety/790.

[5] http://www.bbc.com/news/magazine-26260978.

support of their fellowmen especially at the initial stages of innovation. Second, by developing innovative ideas or products, innovators seek gratification at the personal and immediate community level, and generally don't attach monetary goals to it. Also, having less exposure to the outside world or knowledge of the resources available away from their context, the vision associated with the innovation is usually myopic and hence innovators are not fully apprised of the holistic market demand and size. At the same time, grassroots innovators, even in the absence of notable market demand, are often motivated by an encouraging social environment and work diligently on solving the problems aiming to the community benefit. A society which provides useful network-lateral associations to the innovators, reciprocates the innovative idea in a cooperative and trustful manner, is ready to take a stride on existing social norms, and shares a collective efficacy, fosters more of such initiative in the society by the community's populace even when the market potential seems to be marginal. Hence, environment factors tend to perform a more significant role in the development of GRIs compared to market factors, though not as much as innovator factors do. Therefore,

P1: The positive effect of innovator factors on the feasibility of GRI is greater than that of the environment factors which in turn is greater than that of the market factor.

Outcomes for GRI

Triple Bottom Line theory (TBL) (Elkington 1998) suggests that for a business to achieve sustainability, it should prepare three different bottom lines: (1) the "bottom line" of the profit and loss account, (2) the bottom line of a company's "people account," a measure of how socially responsible an organization has been throughout its operations, and (3) the bottom line of the company's "planet" account, a measure of the firm's environmental responsibility (Hindle 2008). Based on this, as an outcome, we expect GRI to produce sustainable commercial (economic) and non-commercial (social and environmental) values.

Commercial value Following the TBL approach, we define commercial value as "value derived from GRI diffusion measured in monetary form." Grassroots innovators are expected to gain monetary value in the form of revenue and profits generated from the sales of the innovated product, and from the sales of IPR and the licensing of the know-how (Gupta 2006). If the innovation is diffused well, grassroots innovators expect to produce adequate economic value by integrating resources appropriately to fulfill local needs through their innovation and, as a result, to yield a value greater than the costs of the resources (Seelos and Mair 2007; Kumar and Bhaduri 2014). A case in point is the exemplary growth of the GRI Mitticool, the clay refrigerator invented by Mansukhbhai from India, which started with seed money of US$ 420, and has now achieved an annual revenue of US$ 280 thousand in the year 2018 and employs 130 people.

The GRIs granted intellectual property rights and patents earn money from the royalties they receive. Corporations acquiring the IPR or collaborating with the innovator facilitate the commercial value of the given GRI. TATA Agrico, a maker of agricultural machinery, collaborated with Vishwakarma, the innovator of "Sugarcane Bud Chippers," to commercialize the innovation at a large scale. Innovators occasionally receive monetary benefits in various prestigious forums; one such forum is the National Biennial Awards for Grassroots Innovators and Outstanding Traditional Knowledge Holders, where the winning entries are recognized and rewarded by the President of India with sizeable prize money.

Non-commercial values GRIs produce multifold benefits in the community in the form of their social and environmental well-being, which are tough to measure in economic terms. We classify these non-commercial outcomes as: community empowerment, productivity enhancement, social inclusion, and environmental benefits.

Community empowerment occurs when a community believes that it has control or influence over its surroundings, as well as a claim to social, political, and legal rights (Rappaport 1987). GRIs, developed by the grassroots and for the grassroots, work towards the overall well-being of the community through various means, including *employment generation:* the low-cost sanitary napkin making machine innovation led to the employment of 21,000 local women. The increase in local employment empowers the community with greater spending power, increasing their contribution to the economy. Another example of the community's well-being is *health and hygiene*: a healthier community means a healthier and more productive workforce. Innovations such as the Solar Mosquito Destroyer and the Eco-friendly Stove prevent health hazards.

Productivity enhancement occurs with several GRIs, with their aim of reducing drudgery and mechanizing time-consuming activities, providing effective and efficient solutions to enhance the productivity or save man-hours. For example, Mushtaq Ahmad Dar invented the Walnut Cracker, Peeler and Washer, which has reduced the time spent in cracking open every single walnut by hand. The saved man-hours thus could be utilized in other productive activities.

Social inclusion is measured by using a number of primary and secondary indicators that include an assessment of income distribution, poverty rates, unemployment rates, education, health status, etc. (Atkinson et al. 2004; Oxoby 2009). It refers to practices and processes that attempt to include all individuals and communities in the economic, social, and political

development of a region without bias and stigma. For example, Muruganantham's low-cost sanitary napkins innovation benefitted rural woman in terms of health improvement, employment, reduction in medical expenditure on account of health, and increase in productivity at home and work.

Environmental benefits can accrue from GRIs. As opposed to conventional innovations, GRIs are rooted in social and environmental problems that lead the innovators to seek parallel solutions (Seyfang and Smith 2007). Thus, GRIs often take up environmental causes such as water conservation, housing and sanitation, agricultural solutions, food, medicinal innovations, etc. (Ely and Smith 2015). Considering the environmental measures of the TBL, which include waste management measures, fossil fuel consumption, increase in air pollutants, the drawing of excessive nutrients from the environment, and changes in land use and land cover (Slaper and Hall 2011), we can see that even GRIs without an environmental orientation are high on positive environmental impact. By using locally sourced natural materials and minimal mechanization, and by focusing on resource conservation, they typically have a lower carbon footprint (Leach et al. 2012) These grassroots projects are also encouraged by the government to follow sustainability agendas through taxation, incentives, and spread of information (Seyfang and Smith 2007). For example, the clay nonstick cookware innovation uses earthen clay which is biodegradable and eco-friendly as compared to its Teflon counterpart. Thus, GRI ideas and products can facilitate social change not only in their local communities but also at a broader level with positive environmental benefits.

Although GRIs possess inclusive development characteristics and the potential to satisfy all the three bottom lines: profit, society and environment (Feola and Nunes 2014; Smith et al. 2014), it is also true that in the context of GRI the primary objective has always been on achieving the well-being of the society by solving their problems by providing the right set of products at an affordable cost—still the primary reason for the germination of most of the GRIs in the society. Also, GRIs are frugal in nature, and innovators are proficient at incorporating the resources and the raw-materials in their innovative product which are readily available in their environment and ecosystem. Hence, the given GRI is able to bring out the environmental benefits along with social well-being. Also, achieving high profits and revenues are never the primary goal of GRIs. Providing the open licenses and micro-franchising of the innovations validate the intentions behind the GRIs in terms of extracting more of their non-commercial value. This non-commercial value realization contributes further to achieve the economic benefits to the innovators but not as much as the way his innovation can bring about the benefits to the society and the environment. Nevertheless, in the presence of conducive conditions, there can be instances where by achieving a higher commercial value, the given GRI is able to bring improved benefits to the society, either by reducing the cost of the product by producing more in the presence of sufficient funds support, or by having the right market accessibility. So it is expected that the commercial and non-commercial values influence and compliment the growth of each other (which is represented by dotted lines in the framework) under certain conditions discussed in the study. Therefore,

P2: The positive effect of broader diffusion of GRI on non-commercial value is expected to be greater than on the commercial value.

Moderating factors governing the effect of GRI on outcomes

Financial factors *Microfinance* refers to all types of financial services given to marginal innovators/entrepreneurs both in rural and urban setting who do not have access to traditional banking services (Robinson 2001). Innovation systems in emerging economies are plagued by financial challenges (Hossain 2016; Ramani et al. 2012). It is only 11% of grassroots innovators who have access to formal finance, while the rest employ their own capital for innovation activities (Nair et al. 2012). In these economies, a large part of microfinance comes from the informal sector which is not regulated or supervised, while the formal sector micro banking services provide funds mostly at the mature stages of business against some collateral. It is quite evident, from the field interviews and studied GRIs, that the smooth availability of microfinance facilitates the derived value (both commercial and non-commercial) of the given GRI. One such effort is the NIF in collaboration with the Small Industries Development Bank of India (SIDBI) setting up a Business Development and Micro Venture Innovation Fund (MVIF) to promote GRI activities in India.

Cost of GRI Born out of scarcity and aimed at problem solving for people from the lower socio-economic classes, GRIs typically aim at cost minimization in all spheres including production, dissemination, and post-purchase usage and maintenance. It is reported that approximately 83% of the GRIs are offered at a price lower than their MNC alternatives (Nair et al. 2012). This cost advantage is usually derived from locally sourced materials, innovative processes, production techniques, and low labor costs, especially in developing nations (Pansera and Sarkar 2016). The low cost of GRIs is expected to have a positive influence on the acceptance and dissemination of GRIs in society, for example Mitticool refrigerators, low-cost sanitary pads, and clay nonstick pans that retail at a fraction of the cost of their counterparts and attain the popularity among the local community because of their affordable cost.

Marketplace evidence (such as the solar mosquito destroyer, Maruti Jhoola, and mechanized loom) suggests that even after the product shows commercialization potential, the scaling up remains a primary challenge due to lack of funds. The presence of financial support, such as microfinance, will facilitate scaling up opportunities for the given innovation by allowing the innovators to manufacture an optimum number of units to receive profitable margins and, consequently, customers will be able to obtain the innovative product at a low cost. The low cost of the innovative products will facilitate a higher diffusion of the product in the society and hence will generate more units of sales, higher margins, and enhanced revenues, resulting in higher commercial value. And because of the greater availability of the right kind of products at the affordable cost in the given BOP market, the non-commercial value will also be attained in the form of increased performance, better health and hygiene in the community, better employment opportunities for the people at the grassroots, and a strengthened sense of empowerment and inclusion. Therefore,

P3: The conducive financial factors are expected to have greater effect on the commercial value of GRI than on the non-commercial value.

Marketing support *Micro-franchising* is a tool by which the local populace can assist in dissemination of an innovation through the systematization and replication of an enterprise (Fairbourne 2006). It not only supports an innovation by spreading it but also acts as a means of economically empowering the BOP community. For example, Muruganantham used the micro-franchising model to spread his low-cost sanitary napkin innovation across India. With the vision to create one million jobs for rural women and increase sanitary napkin usage in rural India from just 2% to 100%, he offers a micro franchisee of his innovation with an investment as low as US$ 140 to US$ 700 to set up a small manufacturing unit with mini machines along with technical and marketing assistance without royalty or commission. The model has proven to be highly successful so far, having spread to 27 Indian states and 7 other countries with 13,000 units installed. The micro-franchising model has a low start-up time and an extremely low capital recovery time, something which best suits the GRIs targeting the low socio-economic segment.

Publicity has arisen as the synergetic effect of both traditional and social media on sales performance has been well-documented in the extant literature (Kumar et al. 2017). Innovations pertaining to the informal sector benefit from the use of publicity media in spreading awareness and establishing trust in the innovation. NIF, under its Dissemination and Social Diffusion wing, assists innovators in activities such as participating in trade fairs, and creating websites and banners. Moreover, GRI-centric blogs and articles written by experts are spread on the social media, garnering greater publicity and trust among the stakeholders.

While market factors are critical to realizing the overall value of the given GRI, micro-franchising is more likely to affect positively the non-commercial value as compared to the commercial value. The underlying rationale is that as micro-franchising brings about the dissemination of GRIs at a broader level, it performs the important role of empowering the local community by providing employment opportunities and assistance in the eradication of poverty, which consequently will bring a collective increase in personal dignity and well-being (Fairbourne 2006; Amarnani and Amarnani 2008). Because micro-franchising is helping to bring fortune back to the grassroots community and provide better economic conditions to the people at the grassroots, they will be able to increase the sales through personal consumption for the innovative products in the market and hence will derive the commercial value for the given GRI. However, on the other hand, publicity and promotion are likely to bring about the success of commercialization of innovations aimed at the BOP markets (Chikweche and Fletcher 2012), especially in the case of products that require a large degree of awareness before adoption (Ramani et al. 2012), such as agriculture- and health-related innovation. Publicity around the GRIs will create awareness among the community, generate higher market demand, and accrue greater revenues to the innovators. This increase in commercial value will necessitate higher levels of employment and lead to increased productivity and better health conditions, ultimately resulting in higher non-commercial value as well. Therefore,

P4: Within marketing support factors, (a) micro-franchising is expected to have the greater positive impact on the non-commercial value of the GRI than on the commercial value, whereas (b) publicity is expected to have the greater impact on the commercial value of GRI compared to non-commercial value of GRI.

Organizational support *Participation of organizations* can contribute to GRIs. This study refers to an organization as any external entity such as a government agency, non-government organization (NGO), or an academic and/or research body that lends support to the dissemination of GRIs through participation in innovation activities. Such entities, along with contributing modifications and improvements, may significantly expedite the diffusion process by providing scale-up assistance, promotional support, access to finance, collaboration with external agencies, and expanded market access; help in filing patents; and accrue trust among stakeholders by ensuring standardization (De Keersmaecker et al. 2012).

Mainstream industries can also aid the commercialization of GRIs either through lending and sponsoring support, or through purchasing patents and licenses. For example, Future Group partnered with NIF to incorporate GRIs into its service offering to be sold at Future Group retail outlets across India. The innovators were offered royalty on their ideas in exchange for developing affordable products that could be scaled up for the retailer's customers.

Grassroots to global (*G2G) technology transfer* allows GRIs to attain a global platform and reach customers (especially the BOP communities) in other countries/regions with similar needs but with different demographics, culture, geography, and socio-political conditions. The G2G technology transfer process, usually facilitated by the government of two nations or other global bodies, involves adapting the existing innovative idea to the nuances of the adopting region for a better fit (Gupta 2007). For example, technology transfer between India and Kenya of the GRI 'the Shuja tractor' ran into roadblocks on account of terrain disparities. The tractor was modified, with the support of SRISTI and the United States Agency for International Development (USAID), to ensure seamless use by the Kenyan farmers before it found acceptance.

The organizational support at national and international levels is indispensable at almost every step of the value chain, although it is more critical at the commercialization stage in the GRI context. This would be particularly encouraging in bringing out the higher commercial value for the given GRI as compared to the non-commercial value. The underlying rationale is that the organizational support can provide an assurance and instill confidence among innovators and remove uncertainty around the commercialization of their innovation. Therefore, by providing better scaling-up opportunities, broader market access, and building the brand and trust among BOP as well as in the mainstream market, conducive organizational support will facilitate innovators to produce and sell more units and acquire a wider market reach. However, the non-commercial benefits achieved from this would be incremental when compared to the commercial benefits, because only after the realization of commercial value is there a scope for enhancing non-commercial value in these broader markets. Therefore,

P5: The presence of organizational support is expected to have greater effect on the commercial value of GRI than on the non-commercial value of GRI.

Customer characteristics *Community literacy rate* is a factor for GRIs as the BOP/grassroots community is challenged by lower rates of formal education and/or technical and professional education.[6] Marketplace evidence (such as MittiCool) suggests that GRIs which are easy to use and do not require technical learning tend to find favor especially among early users. It is expected that higher literacy rates in the community can enhance the diffusion of a GRI in the community as the populace would be able to understand the use and benefits attached with the innovation leading to better performance.

Knowledge and skills of customers are also factors for GRIs. In the case of technology transfers between India and Kenya with respect to three GRIs, (1) the Shuja tractor, (2) the seed dibbler, and (3) the food processor, the disparity between the entrepreneurial and innovative streaks of Kenyan farmers and Indian innovators gave rise to a challenge in technology adoption. This challenge was addressed by extensive training and capacity building on the part of Kenyan farmers. In instances of technology transfer between two widely disparate communities, technology readiness has a greater role to play in adoption (Tsikriktsis 2004). Thus, the knowledge and skills of the community facilitate the diffusion and commercialization of GRIs through community intellectual/technical input.

Trust in GRI can achieve a higher likelihood of adoption for GRIs when they are endorsed by concerned regulatory bodies and thus garner customer trust, which is why NIF collaborates with leading standardizing and validating bodies to test and validate the innovations.[7] Lacking the advantage of superior formal education, a professional network, technical know-how, and capital to back up their innovations, grassroots innovators find it challenging to generate trust towards their innovations. For example, a GRI that promotes cooking food in iron vessels to increase its iron content faces acceptance challenges among Indian women (Gupta 2016). Validation thus forms an important part of the GRIs' value chains (Pastakia et al. 1996).

When the customers' characteristics are conducive in the given grassroots community, customers will be better able to foresee the benefits of adopting the given GRI and, hence, there is a higher likelihood of achieving a greater non-commercial value within the given community. However, innovators may not be able to achieve greater commercial value in the form of sales and revenues because of the limited market size of their respective community until an innovator reaches out to other geographies and markets. Hence, it is proposed,

P6: The conducive customer characteristics is expected to have greater effect on the non-commercial value of GRI than on commercial value of GRI.

Market accessibility *Market access* not only provides opportunities and resources to grassroots communities, but it also makes them feel inclusive in the society (Farrington and Farrington 2005). While markets have become more

[6] https://data.unicef.org/topic/education/literacy/#.

[7] http://nif.org.in/vard.

accessible with the growth of social media networks, mobile technology, internet penetration, and globalization (Leeflang et al. 2014), the access to this new-age technology may still be challenging for grassroots innovators whose regions lack infrastructure. The presence of the right infrastructure (such as road and railway transport, technology, etc.) is a sign of a nation's overall capability and provides improved market access to businesses. For example, the Mitticool innovator Mansukhbhai, in addition to selling his products in his shop, has set up a website (mitticool.com) and has used mainstream online and offline channels such as Amazon, TradeIndia.com, and Big Bazaar (an Indian retail supermarket) both at the local and global level. Such an expanded access to markets granted Mansukhbhai a push in terms of revenue (approximately US$ 280 Thousand), global reach (such as Dubai, Singapore and Africa), and employment generation (approximately 130 employees) for his local community.

Geographical dispersion refers to the concentration of population over a given territory (Duncan 1957). GRI may follow two different pathways when it comes to diffusion: (1) relational and/or (2) non-relational (Feola and Butt 2017). Relational is when a large number of influential locals adopt the product, and they then spread the positive word of mouth (WOM) through social interactions. However, the diffusion may not always be organic and may be accelerated by the presence of external agencies who facilitate it through exhibitions, free trials, subsidized costs, etc. Non-relational is when the internet supports diffusion growth by providing information and reaching non-local customers at a global level. However, the primary pathway for dissemination remains social interactions. Therefore, the less geographically dispersed the population of a region is, the greater the likelihood of social interactions and therefore the higher the rate of diffusion and adoption.

Market accessibility in the BOP markets determines the spread of new innovation and information throughout the region. There exists a close link between market accessibility and the performance of a regional Innovation System (Andersson and Karlsson 2004). GRIs benefit from better market accessibility by (1) obtaining improved access to multiple sales channels making it easier to reach a wider customer base, and (2) achieving an increased flow of information making it easier to source support for innovative activities in the region from other players. When the market accessibility is low, the given GRI will generate certain levels of economic value and non-commercial value. However, when the market accessibility is high, GRI will generate a higher level of commercial value output compared to the non-commercial value. The underlying rationale is that the market accessibility (meaning better market access and a less dispersed society) will support the given GRI's diffusion among a wider set of customers, create higher demand, and sell more; hence revenue is expected to be enhanced multifold and also expected to bring benefits such as an increased sense of inclusion. However, the non-commercial value will not increase at the same rate as the commercial value because the goods that have been produced already can be sold now (without the need for any additional employment to produce) and only after the sales, the productivity enhancement of the adopters can be realized in newer markets. Thus, we propose,

P7: Market accessibility is expected to have greater positive effect on the commercial value of GRI than on the non-commercial value of GRI.

Discussion and implications

According to Buxton (2008), "The heart of the innovation process has to do with prospecting, mining, refining, and goldsmithing. Knowing how and where to look and recognizing gold when you find it is just the start." The current implications of GRIs are far-reaching; with proper support and guidance, GRIs can turn into a gold mine and achieve sustainable and inclusive growth for the whole ecosystem. The current study develops a framework for diffusion of GRI which focusses on developing antecedents, consequences, and moderators of GRI. Along with the theoretical implications, this study suggests several implications specific to the concerned stakeholders such as the government, non-profit organizations, and business corporations.

Theoretical implications

This study expands the understanding of a BOP-focused innovation which comes from the grassroots, i.e., GRI. Although the existing literature has discussed various issues pertaining to GRI, the concept remains lacking in systematic and structured research on its conceptualization. This study, by proposing a conceptual framework, enriches the GRI literature and provides a comprehensive understanding of the factors driving GRI in a given society and the value it derives from its positioning within the community and the marketplace.

For the first time in the marketing literature, this study, via its proposed framework, employs and links the various theories to discuss the antecedents and outcomes of the GRI. For example, social capital theory describes the environment-related conducive factors, human capital theory explains the innovator factors favorable to the sprouting of more GRIs in the society, science-push and demand-pull theories justify the role of market factors in the context of GRI and the triple bottom line theory explains the outcome value of the GRIs, and suggests that it is the social and environmental bottom lines of the TBL

theory which are more critical for any GRI to be sustainable. The construct development section also invokes the literature about "sustainability" in order to derive the integral characteristics of the GRIs. The conceptualization of GRI also ratifies sustainability as one of the most indispensable attributes in defining GRI as a construct.

GRI, which possesses an enormous potential to contribute to the well-being of the marginalized segments of society, has always been structurally under-researched. Apart from providing a structure to the prevailing work this study conceptualizes GRI as a multidimensional construct and proposes six dimensions to define a given GRI: affordable cost, indigenous knowledge, informal innovation, sustainability, local fit, and adaptability. These dimensions clearly position the GRI in the domain of BOP-focused innovations (Fig. 2 exhibits the overlaps and contrasts among other popular BOP-focused innovations, and Table 3 exhibits the clear positioning of GRI with other bottom-up innovations based on the proposed dimensions). Future research can explore and validate the various components of this framework to strengthen the generalizability of this conceptualization both in the emerging and developed market contexts. The factors discussed as boundary conditions (moderators) will have their own magnitude effect, and depending on the context and the product category of the GRI, exploration of this knowledge can help practitioners as well as theoreticians.

Policy implications

The GRI conceptual framework would be useful in providing government bodies, NGOs, and local development teams with a roadmap for the socio-economic development of the rural and semi-urban community. Similar to the General Electric "global reverse innovation model," which saw the global giants disrupting the healthcare innovation space and bringing healthcare equipment designed for the grassroots to global markets (Immelt et al. 2009), GRIs can also aspire to achieve a global presence. However, unlike the well-oiled machinery of GE with their highly integrated value chain, GRIs depend on government, NGOs, and non-profit organizations to elevate their ideas to a global level. A challenge in this regard is the highly fragmented nature of government departments in developing countries, which often work at cross purposes to one other. Adding to the complexity are a large number of NGOs working in the rural sector. India alone has over 46,331 registered NGOs in total[8] along with several unregistered organizations. Our model highlights the important role of participatory organizations in the dissemination of GRIs, while also cautioning that having too many players without a shared vision and agenda can be more counterproductive than beneficial.

Based on this study, local governments can consider having a dedicated GRI specialized team in every government department that can spearhead the GRI agenda in their respective organizations. For example, both the financing of the GRI through the stages of product development and dissemination, and the difficulties of obtaining finance proved to be crucial moderators in our study. Having a dedicated and trained GRI department in banking and finance institutions would equip them to deal with the unconventional nature of GRI loans. The same is true for technical and marketing support. While the study confirmed the path-breaking work being undertaken by the NIF and academic and research bodies such as IITs in India, not every rural innovator has access to these organizations considering the geographical diversity and remoteness of many rural regions. In such a case, having a local point of contact that can put innovators in touch with the right mentors would help the cause.

The government as a policymaker and facilitator can also use the conceptual framework to understand how to light the spark for self-dependence through innovation that comes from the people themselves. The Indian government in 2014 launched an ambitious "Make in India" program that worked at boosting the Indian economy through a multi-pronged approach of increasing global investments in India, skill development, nurturing innovation, strengthening IPR, and infrastructure.[9] GRIs can become a key contributor in the Make in India campaign, by their inherent characteristics of using local skills, knowledge, and resources to manufacture locally produced goods that cater to local needs. India is also celebrating the years 2010–2020 as the decade of innovation, under which there is an aim to nurture GRI. In light of the commitment to innovation and manufacturing in India, this study gains prominence by providing an understanding of the antecedents and moderators that drive innovation. Our framework suggests increasing the human capital and social capital of innovators though education, skill development, and access to information and opportunities as means to catalyze GRI development. It would also benefit the government/NGOs as facilitators to understand the importance of capacity building within the grassroots community as consumers of GRIs. Capacity building ensures a sustainable demand for the innovation in the future.

The conceptual framework also has widespread implications for co-operative societies that maintain the

[8] https://ngodarpan.gov.in.

[9] http://www.makeinindia.com/home.

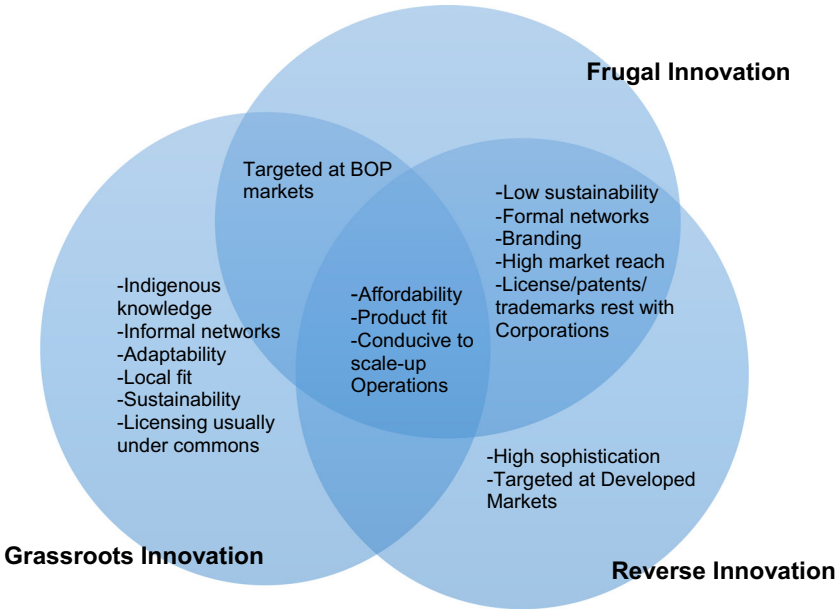


Fig. 2 Comparison of grassroots-focused innovations attributes

collective ownership of GRIs and work on a profit-sharing model, thereby empowering the whole community. Our framework details that an innovator's social network, reciprocity expectation, trust, and social norms, as well as the collective efficacy of the social network, contribute to the social capital of an innovator and consequently affect the innovation development.

Managerial implications

The other implication of this study relates to the managerial community of MNCs and large corporations. A case in point is Future Group's collaboration with NIF to showcase and sell GRIs through their retail chains (such as Big Bazaar) while also collaborating to nurture innovations through their Khoj Lab. The corporates can leverage their business acumen, marketing strategy, scale-up competencies, and supply chain network, assets which rural innovators lack. The innovators, on the other hand, can contribute to the better understanding of local problems and ideas that score high on the GRI construct.

Collaboration with rural innovators can also be an entry strategy for these corporations who can identify potential talent using the innovator characteristics as specified by our framework, and then mentor them to come up with offerings specifically designed for entering BOP markets. Having a dedicated GRI wing within the organization can be a pronounced initiative in this direction. Though such a specialized wing may demand considerable investments without any short-term payoffs, corporations following the TBL approach should not hesitate on such an outlay in order to build a stock for the firm and create a win-win scenario for all the stakeholders.

Table 3 Bottom-up innovation comparison

Innovation	Innovator	Sustainability	Affordability	Indigenous knowledge	Formal institutional support	Local fit	Adaptability
Social Innovation	Govt./NGO/Corporates/Grassroots Individuals/Grassroots community	High	High	Medium	High	Moderate	Moderate
Frugal Innovation	Mainstream Firms	Low	Moderate	Low	High	Moderate	Low
Reverse engineering	Mainstream Firms	Low	Moderate	Low	High	Moderate	Low
Jugaad	Grassroots Individuals	Low	High	High	Moderate	High	Moderate
GRI	Grassroots Individuals	High	High	Very High	Low (Almost nil support)	Very High	High

Other implications

Regulatory bodies, non-profit organizations, and SHGs can further facilitate the diffusion by providing their support at the local level accessible to the innovator and thereby creating the right ecosystem. A few areas, such as understanding the legal and IPR-related issues around the new product development process, creating an awareness and promotion of GRI products, using digital platforms to spread the idea among the concerned community, and receiving validation from authorized agencies to build trust in the market around a given GRI, are critical factors for all grassroots innovators to learn in order to achieve higher sustained value from their innovation. Specialized training at the local level in this area can help them save their interest by understanding the mechanisms of the marketplace and establishing due diligence. Further, the inclusion of students from rural schools and colleges at the grassroots level, facilitated by government bodies, can build an environment conducive to innovations. Nurturing the students at an early age would allow them to build on their human capital, thereby increasing their potential to become innovators.

Future research

Although this study systematically organizes the current knowledge on GRI, explores how GRI works, develops GRI as a multidimensional construct, and proposes a conceptual framework suggesting the diffusion of GRI in society, it doesn't empirically test it. Future research can develop a multidimensional scale for GRI and can empirically test and validate the proposed framework and measure the magnitudes of the moderators. A multidimensional GRI scale would help both government and businesses to gauge GRI development from its early stages and iron out the kinks in the process. Future studies can also extend the current framework by exploring other variables that may moderate GRI outcomes besides financial factors, marketing support, organizational support, customer characteristics, and market accessibility, depending on the study context.

In terms of theoretical contribution, this research has argued for several relationships among the proposed constructs based on field interviews with all relevant stakeholders as well as the marketplace evidence. Future research can further focus on developing theoretical support for proposed relationships using the exploratory versus exploitative framework (Sharma et al. 2018) and/or the resource capability theory (Saboo et al. 2017). While the exploratory versus exploitative theory argues for what makes a GRI successful due to investing in R&D versus marketing, the resource capability theory can argue for what types of capabilities such as operational, technological, and marketing can be conducive to making GRI successful.

The future empirical investigation can be conducted on exploring the effects of GRI on different types of performance outcomes suggested in the marketing literature. Especially in light of Katsikeas et al.'s (2016) study identifying various buckets of performance indicators, it would be enlightening if future research effort could examine how GRI impacts distinct aspects of performance outcomes, along with contingent effects, and thus assess performance trade-offs in the study of GRI at the BOP market level.

This study has been restricted to the Indian context, though the generalizability of this framework is perceived in all emerging markets including Africa, China, and Brazil. It would be thought-provoking to comprehend how different cultures across emerging markets impact the relationships in the framework. This study observed GRIs to be deeply embedded in a socio-cultural context and to draw influence from the society in terms of an innovator's social capital. GRI outcomes are also highly relevant to community benefits and community development as a whole. In this light, future studies could compare collectivist versus individualistic cultural responses to GRI movements. Cultural responses in case of G2G technology transfer could also be explored.

A similar study can also be conceptualized in the developed market context. Future research can also compare and contrast GRIs in the developed and emerging markets. NIF, in collaboration with different government and non-government bodies, has been working to turn GRIs from highly localized movements into a more widely reaching phenomenon. However, the response of other customer segments to innovations that are born out of resource-constraint in the marginal sections of the society needs to be evaluated before such an exercise can be successful. Thus, a study would be significant that explores the factors conducive to the adoption of the GRI product in the upper-middle class and creates an entirely new market for GRIs.

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Appendix

Table 4 Description of some of the innovations considered in the study (select innovations)

Innovation category	Innovation	Innovator	Country	Details about the innovation	Benefits/Outcomes	Innovation picture	Reference
Agriculture	Pepper Thresher	P.K. Ravi	Kerala, India	Unlike other threshers, this innovation can be operated both automatically and manually with higher output and minimal damage.	1) Reduction in crop wastage 2) Reduction in drudgery 3) Increase in threshing efficiency and productivity 4) Supported under MVIF 5) Awarded by NIF		http://nif.org.in/innovation/pepper_thresher/601
	Bullet Santi	Mansukhbhai Ambabhai Jagani	Gujarat, India	Innovation allows for conversion of a Royal Enfield Bullet motorcycle into a multi utility tractor	1) Increases farm efficiency and productivity 2) Reduction in manpower 3) Ecofriendly (higher fuel efficiency relative to tractors and tillers) 4) Patented, 5) National award by NIF 6) Multipurpose (saves investment in multiple machines)		http://nif.org.in/innovation/Bullet_-Driven_Santi/87
	Multi Tree Climber	D. N. Venkat (D. Renganathan alias)	Tamil Nadu, India	Innovation allows for safe harvesting of coconut, rubber, palm and other trees manually through climbing.	1) Reduction in tree climbing accidents 2) Addresses labor shortage 3) Sustainable 4) Supported under MVIF 5) Consolation award by NIF 6) Employement for women (even women can use)		http://nif.org.in/innovation/coconut_tree_climber/471
	Bicycle Weeder, Tiller, Harrow	Gopal Malhari Bhise	Maharashtra, India	Multipurpose farm implement, developed using bicycle components. The implement is adjustable and can be used with different attachments to suit multiple needs like tilling, weeding.	1) Promotes inclusive development (even Marginal farmers can afford) 2) Sustainable 3) Saves manpower and manhour 4) IPR rights with NIF 5) Technology aquired by NIF under GTIAF		http://nif.org.in/innovation/bicycle_weeder_tiller_and_harrow/172
	Walnut Cracker	Mushtaq Ahmed Dar	Jammu and Kashmir, India	The innovation mechanizes the process of walnut cracking which was earlier done manually. Can also be used for almonds	1) Reduction in drudgery 2) Reduction in wastage (reduction in damage to walnut kernels) 3) Health and hygiene benefits (manual cracking led to skin irritation) 4) Environment friendly (device can be both electricaly and manually operated) 5)Awarded by NIF		http://nif.org.in/innovation/walnut-cracker/758
	Sugarcae Bud Chipper	Roshanlal Vishwakarma	Madhya Pradesh, India	A device for removing buds from sugarcane sticks which are then used further for plantation purposes	1) Reduction in wastage (allows pretesting of sugarcane seeds before sowing) 2) Reduction in cost of plantation by 90% 3) Awarded by NIF 4) Supported under MVIF		http://nif.org.in/innovation/sugarcane_bud_chipper/55
	Hand Operated Water Lifting Pump	N Sakthimainthan	Tamil Nadu, India	Simple to use, manually operated water lifting pump used for field irrigation. Innovation has a high discharge at low cost compared to the motorized pumps and conventional hand pumps.	1) Increase in water harvesting efficiency 2) Sustainable (Uses locally sourced materials for production, manual operation) 3) Empowers marginal farmers		http://nif.org.in/innovation/hand_operated_water_lifting_device/357
Health and Hygiene	Mini Sanitary Napkin Making Machine	A. Muruganantham	Tamil Nadu, India	The innovation consists of a set of four different small machines namely de-fiberation unit, core forming unit, sealing unit and UV sanitizing unit, which reduce the cost of production of sanitary napkins.	1) Health benefits for women because of afforsable menstrual hygiene 2) Employment generation 3) Women empowerment (lets women lead a normal life even when menstruating) 4) Multiple State and National Awards 5) Supported under MVIF 6) Prevents loss of manhours due to illness		http://nif.org.in/innovation/mini_sanitary/10

Table 4 (continued)

	Solar Mosquito Destroyer	Mathews K Mathew	Kerala, India	The innovation involves a simple device which makes use of the smell from the septic tanks to attract mosquitoes, which then get trapped in the device.	1) Controls spread of mosquito borne diseases 2) Saves manhours lost due to illness 3) Sustaianble and ecofriendly (uses natural, non-toxic and non-polluting means of mosquito control) 3) Patented		http://nif.org.in/innovation/solar_mosquito/36
	Portable High Efficiency Stove	V. Jayaprakash	Kerala, India	The innovation is a double chambered efficient portable stove used primarily for community cooking	1) Environment friendly (Better combustion efficiency saves fuel) 2) Saves manhours 3)Supported under MVIF 4) Patented 5) Supports community cooking		http://nif.org.in/innovation/Portable_stove_with_high_efficiency/450
	Wound Healing Ointment	SRISTI	Gujarat, India	A herbal and organic wound healing ointment that stimulates the natural healing process.	1) Environment friendly 2) Provides safe, affordable medicinal solution to common cuts and bruises 3) Saves manhours lost due to illness		http://nif.org.in/innovation/wound-healing-ointment/814
	Modified Walker with Adjustable Legs	Shalini Kumari	Bihar, India	Unlike other walkers, the innovation has adjustable self locking front legs that help a person to climb stairs.	1) Improves quality of life 2) Gives elderly and diabled individuals a chance to continue with their employement 3) Empowers elderly and disabled individuals to live normal lives 4) Patented 5) won IGNITE award by NIF		http://nif.org.in/innovation/modified_walker_with_adjustable_legs/672
Non-agricultural occupations and industry	Bamboo Lathe Machine	Imli Toshi	Nagaland, India	The innovation makes use of bamboo waste material combined with locally sourced materials to make a lathe machine	1) Environment friendly (By products from the machine can be further used in other GRIs) 2) Genrates employement 3) Multipurpose (saves investment in multiple machines) 4) National award by NIF 5) Supported by National Mission on bamboo Application (NMBA) funding and NIF		http://nif.org.in/innovation/bamboo_processing_-machine-_--arulepsa/82
	Improved Mechanized Loom	Biren Singh	Manipur, India	A mechanized shuttle loom which simulates the working principles of a traditional shuttle loom, except that the new machine runs fully automatic with the help of a half-horse power motor. Output of the machine is 25-50 times more than the traditional shuttle loom, and almost any other power loom	1) Increased output and productivity 2) Generates employement 3) Reduction in manpower requirement 4) Eco friendly (Made from second hand parts mostly) 5) Quality of woven fabric is better than traditional looms		http://manipurtimes.com/sorokhaibam-biren-the-man-behind-modified-electrical-loom/
	Interlocking Brick Making Machine	Umesh Chandra Sarma	Assam, India	Brick making machine that consists of a brick forming mould and a vibration unit mounted on a chassis. Not requiring a hydraulic press, the machine can make normal bricks as well	1) Affordable housing 2) Ecofriendly (reduces requirment of mortar and less electricity consumption as compared to other machines) 3) Generates employment for women as mostly women are employed in brick making 4) Saves manpower, increases productivity		http://nif.org.in/innovation/interlocking-brick-making-machine/772
	Milking Machine	Raghava Gowda	Karnataka, India	Manually operated milking machine that can be power driven also.	1) Reduction in drudgery 2) Hygienic 3) Addresses skilled labour shortage 4) Reduction in manhours (only 4-6 mins/cow) 5) Eco friendly (mechanical pumping) 6) Patented 7) Multiple awards		http://nif.org.in/innovation/manual-milking-machine/304

Table 4 (continued)

	Multipurpose bicycle	Kamruddin	Rajasthan, India	A modified multipurpose bicycle that serves as a mobile work platform for carpentry, and blacksmithy	1) Employment generation and economic empowerment of marginal communitites (affordable mobile workstation) 2) Energy saving (uses dynamo to power the various functions) 3) Supported under MVIF		http://nif.org.in/innovation/multi_purpose_bicycle/246
	Petrol Performance Enhancer	Hari Narayan Prajapat	Rajasthan, India	The innovation is an easily attachable kit for 4 stroke engines in motorcycles, to increase their mileage without compromising on power. The estimated savings in fuel/petrol consumption is about 10-15 % .	1) Eco friendly (saves fossil fuels) 2) Award by NIF		http://nif.org.in/innovation/petrol-performance-enhancer/607
Lifestyle	Gas-operated Iron	Brahmam, Ajmeri	Gujarat, India	A clothes iron which works on Liquefied petroleum gas (LPG) instead of electricity	1) Reduces drudgery 2) More ecofriendly than traditional coal irons 3) Incubation support from NIF		https://www.business-standard.com/article/companies/innovator-designs-gas-run-iron-box-109100800023_1.html
	Mitticool refrigerator	Mansukhbhai Prajapati	Gujarat, India	A natural refrigerator made of clay that works on the principle of cooling by evaporation	1) Sustainable (made from clay, runs on natural energy, Preserves perishable food items and reduces wastage) 2) Costs a fraction of the cost of conventional refridgerators 3) Awarded by NIF. Part of Forbes 2010 list of 7 most influential rural entreprenuers.		http://nif.org.in/innovation/mitti-cool-refrigerator/751
	Floating soap	C.A. Vincent	Kerala, India	The soap made of milk, honey, oil, caustic soda and soap-nut floats on water. It is manufactured using a specially process that keeps the density at 0.878, less than that of water	1) Sustainable (reduces wastage as a result of the soap sinking to the bottom while bathing in ponds and rivers) 2) Awarded by NIF		http://nif.org.in/innovation/Floating_soap/52
	Maruti Jhoola	Sakrabhai Prajapati	Gujarat, India	An exercise cum health chair. Can be used as a hammock, easy chair, small swing and upper body exerciser	1) Improves quality of life and health 2) Awarded by NIF		http://nif.org.in/innovation/maruti-jhula---an-innovative-health-care-chair/492
	Herbal Bulletproof Jacket	Makarand N. Kale	Maharashtra, India	A lightweight bulletproof jacket made from herbs	1) An affordable lifesaving solution 2) Environment friendly 3) Awarded by NIF		http://nif.org.in/innovation/herbal_bulletproof_jacket/359
	Travel bags with foalding seats	Nisha Chaube	Uttar Pradesh, India	A suitcase with an attached foldable seat that allows the user to sit down while waiting for his commute	1) Comfort for elderly, kids, people with special needs while travelling 2) Reduces dependence on public seating arrangements such as benches, chairs 3) Patented 4) Awarded by NIF		http://nif.org.in/innovation/Travel-bags-with-folding-seats/396
	Non-stick earthenware and cookware	Mansukhbhai Prajapati	Gujarat, India	The innovation comprises of using non-stick coating on conventional clay earthenware and cookware	1) Improves health (low oil cooking) 2) Ecofriendly (made of clay, has life equal to those of conventional non-stick cookwares) 3) Awarded by NIF		http://nif.org.in/innovation/non-stick-earthenware/801

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