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New Product Development in an emerging economy: A multi-objective optimisation approach

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Abstract

Both academia and industry accept unconditionally the significance of new product development and its success in consumer centric businesses. However, one of the key and final indicators of success of any new product "test marketing", has not received adequate attention from both the said sources due to multiple reasons. In this paper, I provide an efficient alternative to this problem by using a "multi-objective mixed zero one linear programming" based method. This improves the performance of the new product development process and successful commercialization of the merchandise. I provide experimental design based validations to support my claim. In addition, I have focused upon a completely unorganized handloom sector consisting of small and medium enterprises in an emerging economy as the frame of reference for the said test marketing – optimization problem. The empirical primary data and business model analysis of the said study area is completely unique to the best my knowledge in terms of academic coverage. Finally, this study provides a feasible managerial solution to the long standing problems of the handloom sector through the application of appropriate optimization methodology.

Keywords: OR in marketing, multiple objective programming, OR in developing countries, new product development, test marketing, experimental design

1. Introduction

A new product is any merchandise or service that differs significantly from the existing offerings. According to Booz, Allen and Hamilton (1982), there are six ways to identify new products. They can be classified as follows:

a) New to the world of products;
b) Having a new product line for an existing market;
c) Additions or supplements to an existing product line;
d) Significant improvements (technology, performance, perceived value, etc.) to existing products;
e) Repositioning of existing products to a new market;
f) Reduction of cost for an existing product.

Evidently, product characteristics as well as choice of target segments play a significant role in defining new products and the said classification covers a significant range of business situations. Hence, in practice, periodic introduction of new products is one of the key business strategies for most manufacturing and marketing firms operating in the consumer market. FMCG (Fast moving consumer goods) companies like Unilever, Proctor and Gamble or technology companies like Samsung are cases in point for the same. Therefore, new product development (hereafter NPD) concept as well as process has received much attention in academic literature. A few significant ones in the last decade are as follows: Lin et al. (2009a, 2009b), Yücel, et al. (2009); Ozer (2011), Özer and Uncu (2015). Liao and Seifert (2015); Lin et al. (2015); Bernstein and Martínez-de-Albéniz (2016); Sale, Mesak and Inman (2017).

NPD has been a significant process for all manufacturing business ventures and especially for end consumer oriented companies. The consumer tastes and choices are reasonably dynamic and the mature merchandise frequently gives way to new selections. However, the NPD process is allied with enormous risk. In spite of frequent new product launches, majority of new products do not survive the initial years. So, the consumer markets are frequently characterized by fragmentation and reconsolidation. As per Ogawa and Piller (2006) and Elaine Wong (2010), new products fail at an estimated 50% rate which could go to as high as 95% in USA and 90% in Europe.

There are overwhelming external and environmental forces that could constrain the success of new product. In addition, lack of scientific process as well as procedural lacunae also play significant roles in new product failures. Most often, firms use empirical primary market research to identify the potential customers of any

proposed new product. However, in the absence of adequate scientific methods and modelling, such techniques alone prove quite unreliable and inaccurate (Mahajan and Wind, 1992; Nijssen and Lieshout, 1995; Bemmaor, 1995). Ozer (1999) provides a summary of the new product development processes, associated methods and methodologies as well as their limitations. Ozer (2005) highlights the frequency of drop-errors and go-errors as one of the key reasons for any NPD failures, investment failures and missed investment opportunities. He identifies NPD process related shortcomings (new product evaluation methods, etc.) and lack of clear guidelines for their usage. Kotler and Keller (2016) too summarize few reasons for the same. Some of the key reasons highlighted by them are "ignored or misrepresented market research, overestimating market size, high development cost, poor design or ineffectual performance of the product, incorrect positioning, poor marketing efforts, high competition and inadequate ROI (return on investments)". Hence, there is need to develop a scientific, efficient and effective method to organize the diverse steps of NPD cohesively and reduce uncertainty of the outcome.

Ozer (2011) identifies the evaluation of viability and market potential for any new product as the key decision parameters and the lack of accuracy of the conventional behavioural methods to predict the said parameters successfully. Wang, Chan and Li (2015) use a fuzzy methodology to develop a superior screening approach and reduce uncertainty in green product development. Kettunen et al. (2015) too highlight the uncertainty associated with NPD regarding its success of product quality and commercialization. They argue for the flexibility to switch development strategies in case of NPD. However, one of the most significant reasons for product failure has not received enough attention in the literature. It is the lack of ability of the firms to conduct test marketing. Test marketing not only helps the firms test the prototype for consumer acceptance and success of marketing strategy, but also helps determine reaction of the competitors and in turn the overall success of the product during commercialization. This point of view has been supported by Kotler, Keller (2016) and Malhotra (2008). In this paper, we have focused upon the test marketing step of the NPD process and developed an alternative scientific method to improve the likelihood of new product success.

Before progressing any further, it is significant to establish the context of this paper. NPD application finds its usage in various businesses viz. FMCG, durable, accessories, fashion and lifestyle etc. As part of this paper, we have chosen the handloom sector of India as the scope. Handloom sector in India is one of the most unorganized economic activities after agriculture and it provides livelihood to more than 5 million people across geographical boundaries (ODC Handlooms, 2015). In addition, handloom weaving is a vital cog in the manifestation of culture in India. The manufacturing as well as purchasing for handloom products is embedded in deep cultural hue due to the behavioural basis (viz. situations, occasions, etc.) of product

usage. The structure of this handloom sector is provided in fig 1. From the diagram, it is quite evident that the weavers and the master-weavers constitute the basis of the manufacturing process. The access to the final consumers market is provided by various government, non-government as well as private agencies. The major activities in the handloom production are raw material procurement (yarns), dyeing, designing, weaving (wrap, weft, etc.) and finishing the product (thread work, zari work, etc.)[1]. As these associated stakeholders are completely unorganized, there are few potent challenges. There is a significant distance between the manufacturing and the end consumers. Technology, competition and consumer's choice are most often dynamic and the manufacturing process is often tradition based. Most significantly, the new products designed by the weavers / firms are almost never tested in the market for their usage and acceptability before the product launch. Hence, the sector is struggling to remain relevant to the present day consumers.

Fig. 1 Structure of Handloom sector

As our current scope of work involves small and medium enterprises (hereafter SMEs) like handloom sector in emerging markets viz. India, we decided to investigate the practice of NPD in the SME sector. Most of the NPD-related work in SME sector involves IT and technology interventions in NPD (Reid et al. (2016), Rehm and Goel (2017), Priyadarshini et al. (2017); Bashir, Papamichail and Malik (2017)). Some of the SME-related work pertains to the manpower issues in NPD process (Felekoglu, Maier and Moultrie (2013), Woschke and Haase (2016)). Huang, Soutar and Brown (2004) developed a model to evaluate the success

[1] dyeing, designing, weaving (wrap, weft, etc.), thread work, zari work, etc. are steps in the manufacturing process of handloom products

of NPD in SME sectors. The influence of external forces and institutional forces in the NPD process of SMEs has also been highlighted by Siu et al. (2006). To the best of our knowledge, there has been no conceptual or applied work on the process of NPD in SMEs like the handloom sector and specifically the test marketing process.

After analysing the literature and practice of NPD process for the handloom sector, we identified the need to develop an integrative optimization based model that would reduce the inherent uncertainty, provide more efficient solutions and improve the probability of success of the new products. Our idea has equivalent resonance from a select set of papers albeit from a very different perspective and purpose (predominantly information processing). Yassine, Sreenivas and Zhu (2008) developed a dynamic programming model for the product development process where they conceptualize each step in the product development process as a sequence of decisions. They analyse and model the sequence of decisions from information requirement and information processing perspective. Nelson, Azaron and Aref (2016) used graphical evaluation and review technique to analyse concurrent NPD processes and model the information and communication complexities. We identified "test marketing" to be completely missing from the NPD application most often and specifically for the handloom sector. In this paper, we develop a multi-objective optimization-based model to supplement the market testing stage. The model can also be used as an alternative to the market testing in case of a constrained environment.

In this paper, we use a multi-criteria decision-making method with multiple objectives over a common set of resources as well as environment-based constraints. A 0-1 mixed linear programming model has been developed to address the NPD optimization problem. We use consumer, competitor as well as supply chain data (raw material sourcing, manufacturer, intermediary, etc.) to build the model. The final solution is a scientific optimization-based approximation to the ideal product design that can reduce uncertainty and increase the probability of success.

In this paper, we provide our contribution in the following way. We extend the NPD literature by providing a method to optimize the market testing stage so as to reduce the inherent uncertainty. We address the uncertainty related to resource allocation decision adequately. Secondly, we study the completely unorganized handloom sector in India for the NPD process. To the best of our knowledge, this sector has neither been studied earlier for NPD or resource optimization purpose nor primary data has ever been collected from Indian handloom sector for the said purpose. We use primary data from the handloom sector of Odisha (a state from India) for empirical research purpose and model building. We solve the model by a novel two stage mixed 0-1 linear programming model as presented in the paper. We also demonstrate the

commercial viability of the results of the optimization model by using experimental design based method carried out in the field.

The rest of the sections of this article are organized as follows. In conceptual development and background section, we introduce the NPD concept, market testing concept and provide a brief on the characteristics of the study area. In the methodology section, we discuss the cluster selection process, primary data collection process, and the hypotheses formulation as well as validation methodology to assert the superiority of the optimization model. We also illustrate the process of identification of the variables through conjoint analyses and structural models. In the problem formulation section, we define the system constraints and objectives using the said variables. In the solution approach section, we present the multi-objective 0-1 linear programming algorithm which is subsequently used for solving the optimization problem. In the analysis and interpretation section, we present the optimization result, interpret the same and highlight its significance in the business environment in the study area. In the validation of the final outcome section, we present the two step experimental design process to validate the final result. We generate hypotheses to validate the superiority of the optimization model for resource allocation trade-off in development of business strategy. It also validates the adequate substitution of market testing with the proposed model. In the conclusion section, we summarize the objectives against the achievements and we present the various contributions (viz. academic, managerial and social) of our research work.

2. Conceptual Development and background

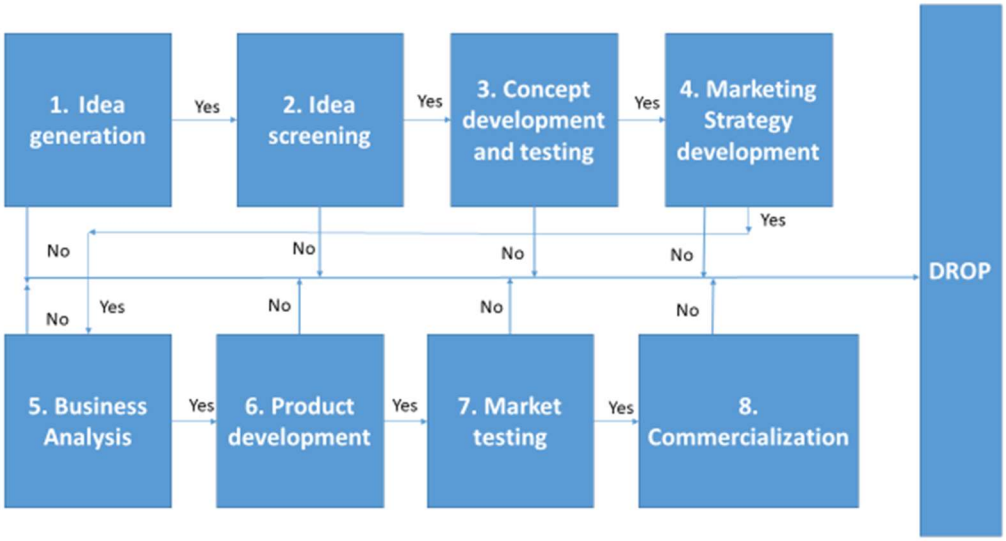
2.1 NPD concept

As per Kotler, Keller (2016), the NPD process consists of eight different steps. The pictorial representation is given in fig 2. Each of the stages involves a definite decision making. The success in the decision making moves the process to the next stage whereas the failure terminates the new product process. Each of the stages could be a potential source of suboptimal and inefficient solution. The steps of decision making in NPD are highlighted below:

1. Idea generation: Search for ideas of new product. The potential sources could be employees of the organization, customers, non-customers, competitors and environmental trends.
2. Idea screening: Identify ideas worthy of further processing. It should be compatible with organizational objectives and resources. It could be evaluated qualitatively or quantitatively.

3. Concept development and testing: Convert ideas to potential products and test them with the consumers for acceptability.
4. Marketing strategy development: Testing the feasibility of an appropriate marketing strategy.
5. Business analysis: Testing the financial feasibility of the new product. Essentially, the profit objective is estimated.
6. Product development: Testing the technical and commercial success of the new product. It involves prototype development and consumer tests.
7. Market testing: Introducing the product in market in a controlled manner and checking its performance
8. Commercialization: Decision making regarding the commercial launch of the product in the market. Often the decisions involve answering the questions when to launch, where to launch, to whom target the product and what is the introductory market strategy.

Fig. 2 New Product Development Process



The effective planning and execution of each of these stages are essential to the commercial success of any product. A brief about the source of sub-optimality is elaborated in table 1. The consequence of the sub-optimality would be rejecting a potentially winning idea, accepting and investing on a faulty product proposition or not being able to ensure commercial success for a good product proposition. The possible course corrections for each step are also presented in table 1.

Table 1 NPD stages, errors and proposition

Serial no.	NPD step	Source of error	Our proposition – course correction
1.	Idea generation	Ideas not being stored; not processed scientifically	Develop a systematic data collection template and storage format; Periodic processing using statistical methods
2.	Idea screening	Drop error; go error	A structured weighted average method of evaluation. The ownership should lie with the resource provider.
3.	Concept development and testing	Completely neglected; lack of knowledge of potential buyers and consumers	Intermediary and consumer survey. Appropriate statistical methods for feasibility
4.	Marketing strategy development	Completely neglected; lack of knowledge of innovative strategies	Product category based marketing strategy inventory, bring in expertise at the master weaver / intermediary level
5.	Business analysis	Only estimate the cost and fix target. No sales estimation	Sales estimation and forecasting at wholesale and retail level
6.	Product development	Faulty prototypes; No consumer tests	Focus on the weavers and master weavers for prototype development; template for consumer tests
7.	Market testing	Not done	Can be estimated with the model
8.	Commercialization	Not having right strategy in place; not ready for alternatives	Expertise at the master weaver / intermediary level; Could involve wholesalers and retailers as stakeholders

2.2 Test Marketing[2]

Test Marketing is the controlled introduction of a product / service to a geographic location or specific demographic group prior to the actual product launch in the open market. This market testing helps in gauging the viability of the product / service from economic, consumer, competitor as well as distribution channel viewpoints. In short, it provides a one-shot test for the success of all the six stages of NPD, provides an estimate of the future of the product in terms of commercial success and provides a feedback from the market regarding the possible course correction (in case, it is needed). This is specifically significant in

[2] Test marketing and market testing are often used synonymously in literature.

case of unorganized markets, unstructured product development processes, dynamic markets and the firms with limited resources.

There are multiple types of market testing catering to different product and market types. According to Kotler, Keller (2016), the consumer goods market testing could include sales wave research, simulated test marketing, controlled test marketing and complete test marketing. Each of the processes involves consumer research, data collection by self-reporting technique, distribution channel data and feedback, and lastly format-based sales performance analysis. The market testing process being longitudinal involves significant time and cost implications. Complete test marketing over a period of few months (2-3) could cost more than $1 million. Hence, this crucial stage is most often bypassed in favour of qualitative channel feedback and expert opinion methods.

2.3 Case study

A real life marketing problem is presented here where new product design has been considered as the basis for the solution procedure. The study is based on handloom clusters in Odisha[3], which produce traditional handloom products. This sector in the study area manufactures sarees (traditional woman wear), dhotis (traditional man wear) and many traditional apparel based accessories (viz. towel, handkerchief, bedsheets, etc.). Odisha occupies a very vital position in the country's handloom product's market which has gained not only national, but also international appeal[4] due to the product's style, design, quality and embedded ethnicity. Naturally enough, a significant portion of the population in Orissa state are weavers and there are master weavers, weaver societies and cooperatives. Such a structure which has existed over decades, ensured better business, cost effectiveness through economies of scale, equal pay for comparable work, a minimum standard of living through regular payment and opportunities for the skilled as well as semi-skilled workers. Financial institutions and banks also support easy finance to enable proper implementation of various government schemes in this regard. So, when handloom clothes production has been a traditional activity highlighting the cultural phenomenon representing its ethnic characteristics whose origin dates back to pre-independence period (<1947), it has to be economically encouraging and should have adequate potentiality for its sustenance even in the present era of globalization.

However gradually, rise in population in the area, increase in cost of living, stagnation in productivity, lack of facilities in technological modernization, poor infrastructure and finally absence of any proper marketing

[3] Odisha is an eastern state in India situated besides the Bay of Bengal.
[4] Sambalpuri, Berhampuri, Bomkai sarees and dresses are popular among Indian women all over the world.

system have led to the destruction of this traditional livelihood of local inhabitants. Also, they are facing competition at the lower end of the ethnic wear market from power looms and textile industries in terms of mass production, lower price points and superior availability. As a result, at present, the sector is incurring heavy loss and most of the weaver's co-operative/societies have become defunct. Many of the master weavers are operating at the lowest level of efficiency. With declining scope for employment in primary agriculture and the other organized sectors of industry, these non-farm activities still constitute the most important economic proposition for people in such rural areas. Hence, the development of this handloom sector not only improves the economic scenario of these underdeveloped regions, but also maintains cultural identity in a pluralistic society like India.

The handloom segment is part of the SME sector. Hence, there are limited resources and budget is always a constraint. In addition, the product design and subsequent production process has been the livelihood of weavers for generations and hence there is a cultural orientation to it. The purchase and usage of the handloom products by the end consumer also have behavioral alignment (viz. special occasions, situations, purpose, etc.) and hence there is a cultural significance of the products for the end consumers too.

Obviously, the problems here are multidimensional and require a holistic approach for their solution. However, among all these problems, one of the very significant factor is the diminishing demand for handloom products at the middle and high end market. Consumer appreciation and preference for the handloom products from Odisha at the mid and high ends is gradually declining. Being a consumer-based business, development of new products is a key economic activity in the handloom sector of Odisha. Apart from producing conventional designs in manufacturing traditional wear and accessories, weavers spend up to 40% of the total productive time in new products and new designs. The declining market for handloom products made us study the NPD process and its effectiveness in the handloom sector in Odisha.

3. Methodology

The study methodology is divided into three parts. In the first part, we choose 18 handloom clusters[5] that have higher productivity and better business success ("A" category as per Government of Odisha classification). Also, we have chosen these clusters based on their propensity towards innovative practices and experimentation. We observed the production cycle of these handloom clusters and chronicled the

[5] Geographical concentration of SMEs that are involved in handloom business. We chose handloom clusters in Bargarh, Cuttack, Subarnapur, Boudh and Jajpur districts of Odisha.
http://218.248.11.68/textilehandloom/ImpClusters.asp?lnk=3&PL=5

conventional NPD practices as well as the outcome. In the second part, we use the data collected during part one of the study, carry out further data collection and analysis to identify the potential consumers and build the product – market strategy. In the third part, we develop the business model and value chain along with the financials for the chosen product market strategy. Subsequently, we generate the objectives and constraints for the optimization model and validate the same using appropriate structural model.

3.1 Part –I

The conventional process of NPD in handloom sector is described in table 2. No structured and scientific process is followed through the production process. The manufacturing cycle (Tie and dye to weaving) for a saree is often 5 days. For a standard silk saree, the procurement cost for the intermediary / master weaver is around Rs.1600/- per saree. In the local market, the saree is sold for Rs.2500/- (56% margin); whereas in larger cities, the price could be between 200% and 215% for the end consumer. However, there are varieties of raw materials and product designs and hence the manufacturing cost of sarees vary from Rs.1600/- to Rs.5600/-. We observed all the handloom clusters for a period of 6 months and saw 50 new designs other than the conventional designs. The chosen clusters had 300,000 looms (approximately) between them and more than 72, 00,000 sarees were manufactured. The ratio of traditional to new design manufactured was 70:30. From the 50 new designs, 5 were successful (all were sold out) in the next 3 months. The approximate financial performance of the end products from the 18 handloom clusters is provided in table 3. So, while the design of the new products in handloom sector is quite essential to remain relevant in the emerging market scenario, the success of the new products remains a challenge.

Table 2 Conventional NPD in handloom clusters

Serial no.	NPD step	Source	Activity
1.	Idea generation	Design ideas are often by weavers. Sometimes suggestions by master weavers, intermediary or NGOs / cooperatives	No structured process is followed
2.	Idea screening	Ownership lies with the one providing funds. Any stakeholder identified in exhibit 1 could be involved with the approval.	No structured process is followed
3.	Concept development and testing	Family members / local population are involved in product acceptance study	No structured process is followed. Master weavers or intermediary approve concept development

4.	Marketing strategy development	Weavers along with master weavers / intermediaries	Predominantly pricing is done based on cost of manufacturing. Distribution is predominantly conventional and the existing distribution network is used if they agree to stock the product. Product portfolio analysis or promotion does not play any part here.
5.	Business analysis	Target for manufacturing is fixed by the weavers / master weavers based on the order by the intermediary / retailers	Individual intermediaries do their own sales analysis and estimation. Based on the same, they place orders / purchase merchandise from the weavers
6.	Product development	Weavers and master weavers	Quality and consistency checked by the weavers / master weavers. It is more a question of their values and honour rather than consumer survey
7.	Market testing	Not done	Not done
8.	Commercialization	The funds provider. Often, it is the master weavers and intermediaries (includes NGOs and cooperatives)	Orders are already placed by the wholesalers / retailers for the product. So, it is order supply within the agreed time period. Time of product launch is crucial; festival periods are preferred.

Table 3 Financial performance of the handloom products from the handloom clusters

	No. produced	% sold	Sales turnover period in days	Repeat orders
Conventional design	50,40,000	70	30–60	90% of times
New design	21,60,000	20	120	50% of times

3.2 Part – II

In this part, we present an NPD process for designing handloom products (saree). We use additional data and statistical analysis from the same handloom clusters for the said purpose. Subsequently, we develop and use a multi-objective optimization model to augment resource allocation as well as business decision making. As an output, we provide definitive input to the product strategy and appropriate resource allocation plan, which helps the decision maker on the next course of action.

3.2.1 Consumer identification

As a first stage, we conducted a survey and appropriate clustering technique to identify the potential customers for the product. We took into consideration the domicile locations of the potential consumers, their income, lifestyle, situations, occasions as well as purposes of product purchase as these are the factors that have considerable influence in the product purchase. We developed a multidimensional and multilevel segmentation instrument and used cluster analysis to identify four significant consumer clusters. Their brief profile is given below.

3.2.1.1 Group-1 type

This type of consumers has affluent status. They normally reside in posh areas and better localities. They are normally highly educated, businessmen or high officials in government or private sectors. They have high income and hence, higher standard of living with access to national and international markets. Normally, they are high-risk takers, extroverts, innovative swingers with low involvement in purchase-related decisions and fluctuating attitudes. They go for frequent purchases with interest-based awareness about markets, but their usage rate of goods is normally less. This cluster constitutes 14.5% of the total market.

3.2.1.2 Group-2 type

These types of consumers are from upper middle class. Normally, they are highly educated business people or professionals in various fields, with better income and having access to the national market. The middle age groups of this class are normally prime decision makers. These people are normally achievers who seek recognition. They are evaluative innovators, moderate risk takers; switching loyal or softcore loyal with high involvement having rational decision-making ability, cognitive attitudes, and significant learning behavior. They have better awareness and are prestige, status and value conscious people having strong attachment to local culture. This cluster constitutes 21.25% of the total market.

3.2.1.3 Group-3 type

They are the lower-middle class people who normally have average educational level and limited income. They are workers from government or private sectors having access to local market only and are normally driven by security and social needs. They are introvert or aggressive, low risk takers, opportunistic switchers and prestige conscious. Their purchase behavior is normally active type with highly probing involvement and a lot of price sensitiveness. They expect maximum value for money, but on occasions they can be emotional and impulsive. They have got much to complain about everything in life. This cluster constitutes

45% of the total market.

3.2.1.4 Group-4 type

These consumers are middle class conservatives with rich background and traditional approach and belief to life. They are people with aristocracy, with property by inheritance and with their own business or they are in government service. Hence, they are conventional people with proper education, better income, with concrete belief on their opinions and strong attachment to traditional institutions. These believers are mature, satisfied, comfortable and reflective people who value knowledge and responsibility; they possess moral codes, which are deeply rooted in their value system. They follow established routines and are not so open minded about new ideas and social changes. They have decent awareness about products in the market even though they prefer status quo. They take low to moderate risks with similar involvement, but on occasions, they can be more emotional and impulsive. They are heavy brand loyal with modest yet sufficient needs. This cluster constitutes 19.25% of the total market.

As the lower end of the apparel and accessories market is saturated with power loom based organized players, focused targeting of mid–upper and niche segments would be the ideal strategy for handloom products. Hence, consumers with lower purchasing powers or serious resistance to change were not considered ideal for the new products here. Groups 1 and 2 were selected for subsequent study in the NPD process.

3.2.2 Concept testing with the chosen target groups

We used the product ideas generated in the conventional product design process (part I). We developed conjoint designs for each target segment identified in the previous stage. We technically dissected the product concept to identify the key decision areas and the associated options. We developed the orthogonal design and based on the same, digitally designed the end product prototypes. The prototypes were presented to the target groups for rating in ten-point scale. The resultant conjoint output summary is presented in table 4. Based on the part-worth and utility score, we identified 32 different designs with 70% or more rating score from the consumers. We used the top ranked design to develop marketing strategy.

Table 4 Conjoint output summary for concept testing

Serial No.	Factors	Part-worth Group 1	Part-worth Group 2	Attributes	Utility Group 1	Utility Group 2
1	Raw Material	18.5	22.2	Silk	-4.8	4.3
				Cotton	2.6	-1.5
				Tassar	2.2	-2.8
2	Border Design	17.5	19.4	Animal, Birds	-2.4	3.8
				Flowers. Leaves	1.0	-2.1
				Social Events	1.4	-1.7
3	Body Design	18.7	12.8	Booty	1.5	-2.2
				Self-colour print	0.8	4.2
				Wide Stripe	-2.3	-2.0
4	Colour	15.7	17.7	A1	2.1	4.0
				C11	-4.5	-3.0
				B3	2.4	-1.0
5	Area design influence	19.8	18.9	Sambalpuri	-2.77	3.9
				Bomkai	0.92	1.5
				Pochampalli	1.85	-5.4
6	Consumer Segment	9.8	9	C1	1.36	2.7
				C2	-1.98	-1.2
				C3	0.62	-1.5

3.2.3 Hypotheses testing for marketing strategy

In order to develop approximations for appropriate marketing strategy, we decided to focus on the classic 4P decisions (product, price, place, and promotion). We already had the product available. The price decision had three options (viz. market price, lower than market price and higher than market price). The place decision had four options (viz. local market general store, mid-sized apparel-based retail store, large-sized branded apparel and lifestyle store, government cooperative store). The promotion decision had four options (viz. radio, regional language newspaper, national chain newspaper, fairs and exhibitions, etc.). In order to test the hypotheses regarding the suitability of the various marketing strategies, we chose another conjoint-based model on the group 1 and 2 consumers. The summary of conjoint results is provided in table 5. For group 1 consumers, for the same product design, higher than market price, large-sized branded apparel and lifestyle store, national chain newspaper, fairs and exhibitions, etc. was the preferred choice for marketing strategy. For group 2 consumers, lower than market price, mid-sized apparel-based retail store and radio was the preferred marketing strategy.

Table 5 Conjoint output for marketing strategy

Serial no	Factors	Part-worth group 1	Part-worth group 2	Attributes	Utility group 1	Utility group 2
1	Price	28.6	42.7	Market price	7.7	3.4
				Lower than market	-5.5	1.7
				Higher than market	-2.2	-5.1
2	Place (distribution)	21.4	38.1	Local retail	1.1	-6.3
				Mid-sized general store	-3.0	2.4
				Apparel-based national chain	-2.5	1.5
				Government cooperative	4.4	2.4
3	Promotion	50.0	19.2	Radio	1.1	2.2
				Regional newspaper	1.1	1.8
				National newspaper	-4.5	-6.3
				Fairs, exhibitions	2.3	2.3

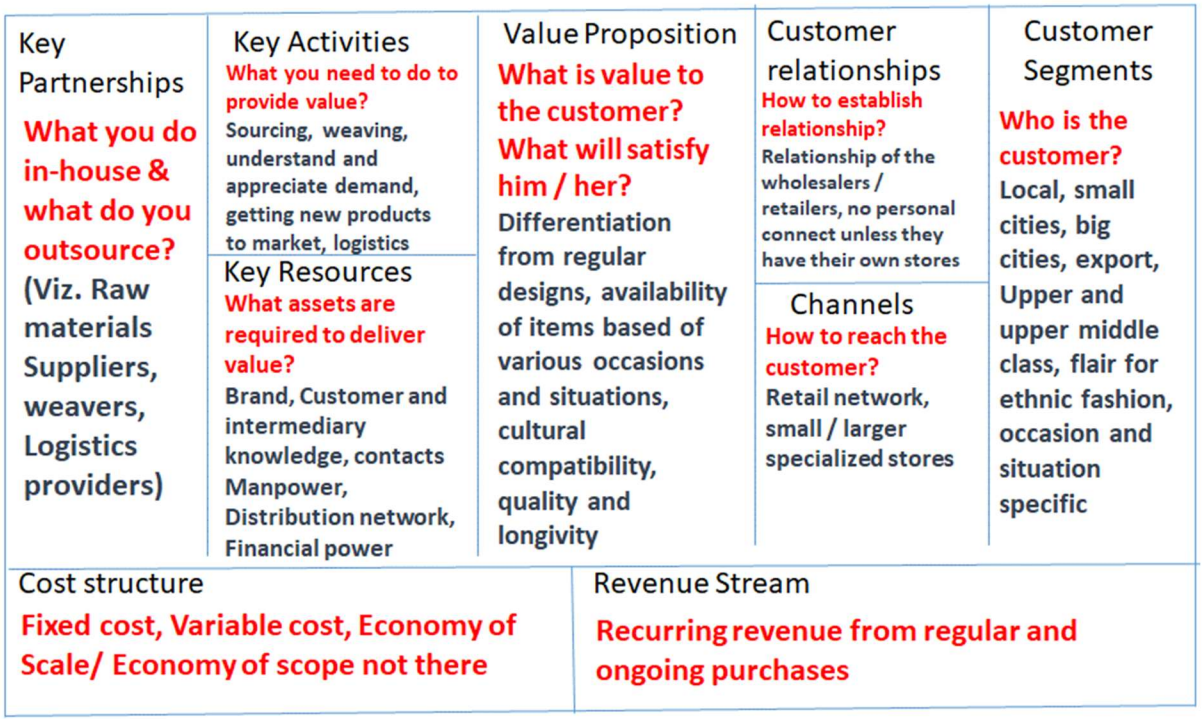
3.3 Part-III

3.3.1 Constraints

We started this stage with a clarity to identify the various stakeholders in the handloom business from a master weaver / society / cooperative perspective, define their roles and responsibilities as well as major challenges. In the end, we wanted to identify the root of success in this business. We used the structured business model template (Osterwalder, Pigneur, 2009) and developed the business model for handloom products (fig 3). From the business model, we identified the key challenges to the handloom business. Each of the defined challenges has financial implications (cost / revenue).

a) Availability of raw material in right amount, price and at the right time
b) Logistics provider capacity and efficiency
c) Retail and wholesale capacity and efficiency
d) Manufacturing capacity, efficiency and quality
e) Availability of skilled manpower
f) Financial capacity
g) Relationship with the distribution network
h) Relationship and engagement with the end consumers
i) Choosing the right customer segment and the right retail format, as well as promotion to reach them effectively
j) Availability of merchandise for various occasions, situations and purpose
k) Congruence with consumer culture and weaver culture

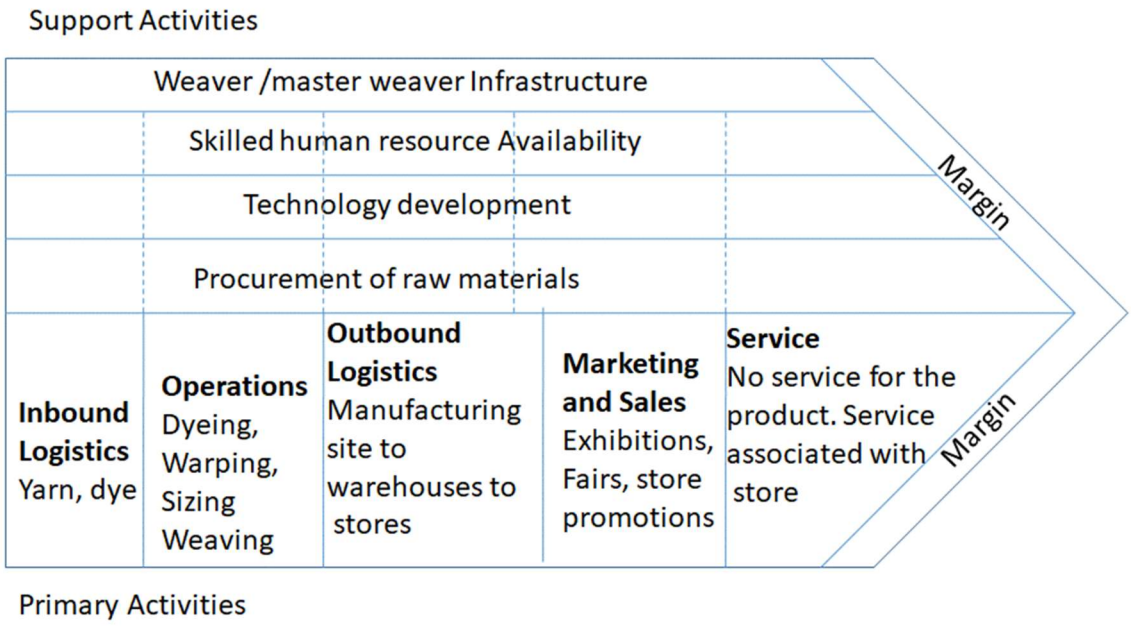
Fig. 3 Business model for handloom products – Master Weavers, cooperatives, and societies' perspective



3.3.2 Objectives

After identifying the significant challenges, it was important to define the value delivery and its success (in spite of the challenges). This is the key to development of a model that optimizes resource allocation within the challenges present in the system and in turn integrates with the objectives that are central to the success of the handloom sector in Odisha. We wanted to confirm the objectives through the analysis of the value delivery process. In other words, we wanted to check which activity leads to how much value addition and for whom. We used Michael Porter's value chain to arrive at the value to the end consumer. The value chain is presented in fig 4.

Fig. 4 Porter's value chain for handloom products – Master weavers, societies, and cooperatives



We also developed an income statement (table 6) parallel to the value chain for the handloom merchandise (saree) production process to understand the margins to the various stakeholders.

Table 6 Income statement for manufacturing handloom products

Category of costs / margins	Actuals / INR	In Rupees (INR)
Total variable cost		82.5%
Materials		
	Yarn	32%
	Dye and chemicals	9%
Labour		
	Warping	9.5%
	Sizing	7.5%
	Weaving	24.5%
Total fixed costs + overheads		17.5%
Total cost	1600	100 (say)
Margin for the manufacturer / weaver	160	10%
Margin for the Master weaver / cooperatives	528	30%
Margin for the intermediary	686 – 1144	30% - 50%
Price for the consumer (includes taxes)	2974 – 3432	200 – 215 (Say)

Analysis of fig 3, 4 and table 6 helped us identify a few crucial objectives for the success of the handloom sector.

1) To keep the cost level minimal (within available resources) by optimizing the operations, adopting technology and improving the efficiency of manpower
2) To boost the demand by identifying right customers for right category of products, using marketing and sales channels efficiently to position the products appropriately and engage with the consumers frequently to increase loyalty
3) To grow capacity at the supply side by improving raw material procurement, efficiency in manufacturing, efficiency in distribution network and ensuring sustainability of the business in the long run
4) To ensure cultural compatibility
5) To ensure the survival of the organization in the short and medium run
6) To engage with the consumers on various platform continually and improve loyalty for the product
7) To work towards developing a regional brand for superior recognition, recall and bargaining power

3.3.3 Validity of the relationships

To reconfirm the validity of the objectives and challenges for the handloom business, we decided to develop a structural model and check the relationship between various variables. We generated all the observable factors that could potentially influence the success of the handloom business from the master weaver / societies / cooperatives perspective[6], developed a questionnaire and collected data on the said questionnaire. We carried out an exploratory factor analysis (Principal Component Analysis) to identify the underlying dimensions. We identified 5 different components which would be constraints to the optimization model. The constraints are capacity based, design compatibility based, cultural compatibility based, consumer preference based and current practice selectivity based. The detailed explanation for these constraints is provided in the problem formulation section.

Subsequently, we developed a structural model (Confirmatory Factor Analysis) with the pre-identified variables and the objectives identified by us (explained before in this section). We generated a first order 3-factor model. The path diagram is presented in fig 5. The model statistics is given in table 7. The three latent variables identified are cost, demand and growth, respectively (details are provided in the problem formulation section). As we have validated the key objectives and constraints for a resource allocation model that would help deciding the potential success of the products under consideration in commercialization stage, we move to the problem formulation stage.

[6] To bring about more relevance and practicality to our research, we collaborated with 2 master weavers and developed our model for the success of their handloom business for a single product line.

Fig 5 Path diagram for the first order CFA

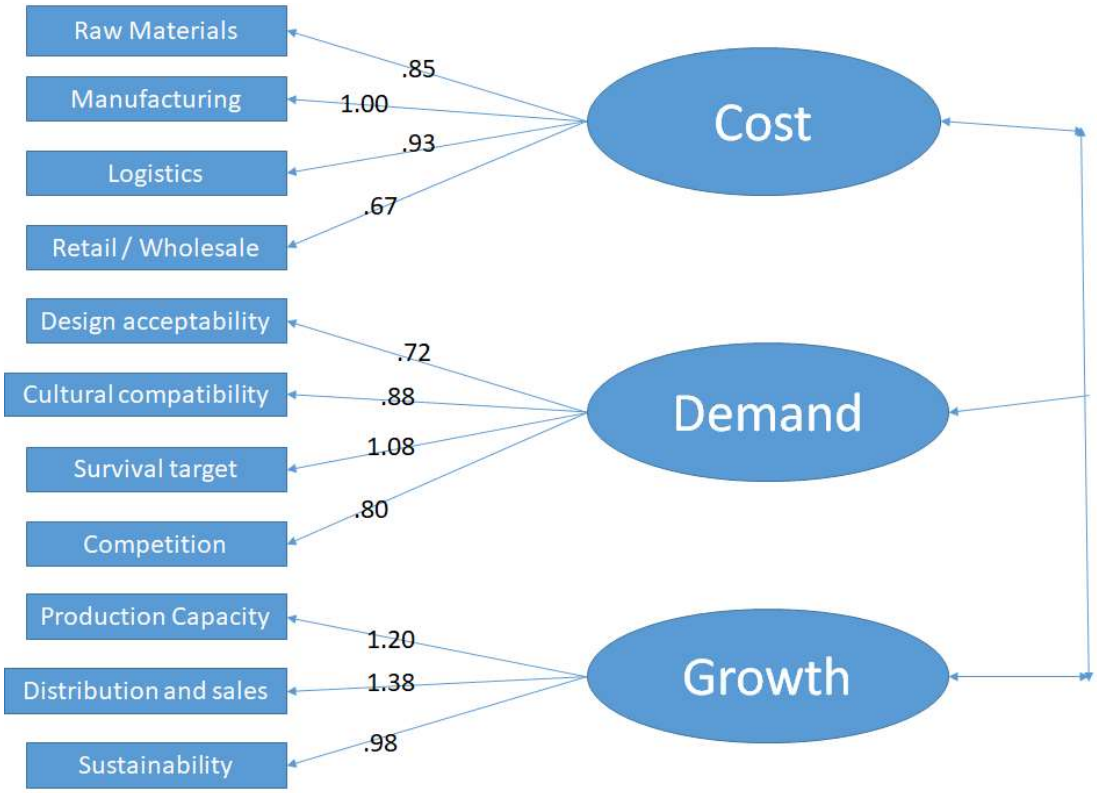


Table 7 Structural Model goodness-of-fit

Serial No.	**Goodness-of-fit**	**Function value**
1.	Chi Square	1447.57 (df=609)
2.	RMSEA	.049
3.	NFI	0.70
4.	NNFI	0.74
5.	PNFI	0.60
6.	CFI	0.77
7.	GFI	0.88

4. Problem Formulation

The decision variables, constants and symbols for the problem formulation are as follows:

4.1 Decision variables, Constants and Symbols

i : 1,2 for input raw material for handloom saree, viz. , silk and tasar, respectively.

i_1, i_2 : Two different raw materials

j : 1,2 for various border designs of handloom saree, viz. , animal / bird and social events designs, respectively.

j_q, j_{q+1} : Two different border designs

k : 1,2 for various body designs of handloom sarees viz., booty and wide stripe, respectively.

n : 1,2 for different cross-cultural designs of handloom sarees with input quality i, border j, and body design k viz., Sambalpuri, Pochampalli, respectively.

m : 1,2 for different consumer segments Group 1 and Group 2.

(i,j,k,m,n) : i^{th} quality input raw material with j^{th} type border k^{th} type body design, and n^{th} culture specific cross-cultural saree design pattern targeted towards m^{th} consumer segment

$X_{i\ j}^{k.m.n}$: Handloom saree with i^{th} quality input raw material with j^{th} type border k^{th} type body design, and n^{th} culture specific (cross-cultural) saree design pattern targeted towards m^{th} consumer segment

$C_{i\ j}^{k.m.n}$: Cost incurred for handloom saree of type (i, j, k, m, n)

$CD_{i\ j}^{k.m.n}$: Current demand for handloom saree of type (i, j, k, m, n)

$I_{i\ j}^{k.m.n}$: Income generated for handloom saree of type (i, j, k, m, n)

M : Total budget allotted for the cross-cultural saree

Here, color is not considered as a variable for problem formulation because of the inability of the manufacturing process to accommodate the new proposed colors during the study period. However, it can always be considered at a later phase once the technical feasibility is ensured.

The formulation for system objectives and constraints is given below as follows.4.2 System Constraints:

4.2.1 Raw Materials

There are various types of products and various qualities of input raw materials (i.e., pure silk, Tasar, etc.). Also, there are so many border designs and body designs. However, each type of raw material would not be compatible with every design pattern. Hence, market acceptability may also be a challenge. In addition, there are sourcing constraints too. All raw materials are not available in every season. Hence, selection of final product would be constrained by raw materials. Mathematically it can be put as:

$$\sum_j \sum_k \sum_m \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, i$$

$$X_{i_1 j}^{kmn} \leq X_{i_2 j}^{kmn} \qquad \forall\, i$$

4.2.2 Non-Compatibility of Border-Body Design:

There are so many types of border and body designs along with various product lines. As each product cannot be manufactured from any raw material, each product cannot have every possible combination of border and body design because of infeasibility in the manufacturing process, unsuitable marketing facilities or lack of acceptability in the market. This constraint avoids all such possibilities. Mathematically, it can be put as:

$$\sum_i \sum_j \sum_m \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, k$$

$$\sum_i \sum_k \sum_m \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, j$$

$$\sum_i \sum_m \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, j,k$$

$$X_{ij_q}^{k_r m_s n} \leq X_{ij_{q+1}}^{k_{r+1} m_{s+1} n} \qquad \forall\, j,k$$

4.2.3 Preference:

Preferential constraint really determines which specific product or combination of products is preferred to others. This preference can be due to culture-specific design patterns, material quality, border or body design of the product, etc., where one product is expected to be better than others from consumer point of

view. In addition, handloom products have occasion and situation specific preferences that depend upon the consumer segment and their purpose of purchase. Mathematically, it can be put as:

$$X_{i_q j_r}^{k_s m_t n_u} \geq X_{i_a j_b}^{k_c m_d n_e} \qquad \forall\, i, j, k, m, n$$

$$X_{i_q j_r}^{k_s m_t n_u} + X_{i_{q+\theta} j_{r+\theta}}^{k_{s+\theta} m_{t+\theta} n_{u+\theta}} \geq X_{i_a j_b}^{k_c m_d n_e} + X_{i_{a+\beta} j_{b+\beta}}^{k_{c+\beta} m_{d+\beta} n_{e+\beta}} \quad \forall\, i, j, k, m, n$$

4.2.4 Cultural Non-Compatibility:

There are multiple cultural influences in the handloom products business. The weavers' culture and their manufacturing heritage, the consumer culture and their purchase behavior and the regional culture are significant in supply chain behavior as well as consumer purchase decision-making process. All these need to be mutually compatible for the success of any handloom product. These constraints remove all non-compatibility from the choice list for effective product attribute mix design. Mathematically, it can be put as:

$$\sum_i \sum_j \sum_k \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, m$$

$$\sum_i \sum_j \sum_k \sum_m X_{ij}^{kmn} \leq 1 \qquad \forall\, n$$

$$X_{i_1 j}^{k m_1 n} \geq X_{i_1 j}^{k m_2 n} \qquad \forall\, m$$

$$X_{ij}^{k m n_1} \geq X_{ij}^{k m n_2} \qquad \forall\, n$$

$$\sum_m \sum_n X_{ij}^{kmn} \leq 1 \qquad \forall\, i, j, k$$

4.2.5 Minimum Selectivity and Competitive Advantage:

In spite of all modern developments and innovations in products, some basic items cannot be neglected. Selection of those items is suggested in this constraint. Actually, the products, which are available, now, are appreciated in core consumer segments based on occasions (used in specific festivals, occasions, and rituals) and considering ethnic values, this product line cannot be suddenly divested. Besides that, the competitor's and current market leader's long drawn experiences and innovation activities can be treated as a base. So, the system needs to take advantage of that by producing a minimum amount of the already accepted products. This would not only ensure a competitive parity at present, but also would enhance status

and approval of the organization in future. So, mathematically, it can be put as:

$$X_{ij}^{kmn} \geq 1 \qquad \forall\, i, j, k, m, n$$

$$\sum_{i}\sum_{j}\sum_{k}\sum_{m}\sum_{n} X_{ij}^{kmn} \geq 1 \qquad \forall\, i, j, k, m, n$$

4.3 System Objectives:

4.3.1 Cost Objective:

NPD is an essential component of the business model for handloom products and the success of any NPD depends heavily on test marketing. However, NPD process itself is quite expensive and cost of test marketing could potentially exceed that of all other steps. Hence, cost is one of the most significant factors in SME sector (viz. handloom) due to limited availability of resources and the pressure on margins to become profitable. So the objective of cost is to be minimized. Mathematically, the objective functions can be defined as:

$$Min \sum_{i}\sum_{j}\sum_{k}\sum_{m}\sum_{n} C_{ij}^{kmn}\left(X_{ij}^{kmn}\right)$$

4.3.2 Demand Objective:

Demand is defined as consumer's desire backed by ability and willingness to pay. Demand for any product can be computed as follows:

D = n * q * p

D:	Total market demand for the product.
n:	Number of potential buyers for the specific product
q:	Quantity purchased by average buyer.
p:	Price of the average unit.

Estimation of demand indicates the consumer side of the bargain. For the success of any product, a superior and sustained demand is most essential. Hence, the objective of current demand should be maximized and mathematically, it can be represented as:

$$Max \sum_{i}\sum_{j}\sum_{k}\sum_{m}\sum_{n} D_{ij}^{kmn}\left(X_{ij}^{kmn}\right)$$

4.3.3 Growth Objective:

Growth, symbolizes the development in future in terms of market share of the product line / product category. Naturally, a growth in market share would be based on increase of sales which in turn would depend upon growth in efficiency of the entire NPD process. We include sourcing (raw material) efficiency, supply chain efficiency, manufacturing process and capacity development as well as distribution network efficiency for computation of growth in this model. While the demand objective captures the consumer side of the business model, growth is designed to capture the manufacturer and supply side efficiency. We aimed for a market share of 5% in the mid and high segments of the handloom sector. We followed conventional GDP growth rate computation method to compute growth in the handloom sector. We collected time series data (last 5 years) for the primary and support activities of the handloom sector value chain (fig. 4) and identified the growth rate. Subsequently, we computed a cumulative growth value (in monetary terms) and projected it for a 5% market share of the handloom products. As the current practice is 30% new products against 70% existing products, we computed growth numbers (in monetary terms) for the products chosen by us. Mathematically, the objectives of growth are represented as:

$$Max \sum_{i}\sum_{j}\sum_{k}\sum_{m}\sum_{n} I_{ij}^{kmn}\left(X_{ij}^{kmn}\right)$$

4.4 (0, 1) Restrictions:

Each decision variable has to take a value 0 or 1 as its solution. Mathematically, it can be represented as:

$$X_{ij}^{kmn} \in \{0,1\} \qquad \forall \quad i,j,k,m,n$$

5. Solution Approach

The problem stated in the previous section can be explained in terms of a multi-objective 0-1 linear programming (MO01LP) model as:

$$\begin{aligned} & Min\ O_1(x) \\ & Max\ O_2(x) \qquad \ldots\ldots\ldots \qquad (1) \\ & Max\ O_3(x) \\ Subject\ to: \quad & A.X \leq b \\ & B.X \geq d \\ & X \in \{0,1\} \end{aligned}$$

Although there are some approaches in the literature (Bitran, 1977; Deckro and Winkofsky, 1983; Kiziltan and Yucaoglu, 1983; Rasmussen, 1986; Mavrotas et al, 1999; Azigoglu and Özlen, 2009; Przybylski et al. 2010; Przybylski and Gandibleux; 2017; Boland et al. 2017) to solve the model (1) for non-dominated solutions, we propose a two stage MOM01LP approach that combines two mixed 0-1 linear programming (LP) models using two aggregation operators. The first model is a competitive decision model that generates a solution while giving equal importance to all the objectives considered for the problem. The solution thus obtained is then improved for its non-dominance by a compensatory decision model in the second stage. The steps of this integrated approach are described below.

Step-1: (*Assessment of the solution range)*: We assess the solution range of all the three objectives with respect to the mentioned constraints where $X \geq 0$. For that, we solve the MO01LP model as three independent LPs taking one objective at a time with respect to the constraints $A.X \leq B \; and \; X \geq 0$. Hence, we get three optimal solutions for the three objectives. These solutions are the best targets for the three objectives. For example, if $O_i(x) : i = 1, 2, 3$ are the three objectives and $x^j : j = 1, 2, 3$ are the corresponding optimal basic feasible solutions, we construct the following pay-off matrix with $O_1^*(x^1): i = 1, 2, 3$ as the ideal target.

$$\begin{array}{c} \\ x^1 \\ x^2 \\ x^3 \end{array} \begin{array}{c} \begin{array}{ccc} O_1(x) & O_2(x) & O_3(x) \end{array} \\ \begin{bmatrix} O_1^*(x^1) & O_2(x^1) & O_3(x^1) \\ O_1(x^2) & O_2^*(x^2) & O_3(x^2) \\ O_1(x^3) & O_2(x^3) & O_3^*(x^3) \end{bmatrix} \end{array}$$

Then we normalize the solution range of each $O_i(x) : i = 1, 2, 3$ based on O_i^B and O_i^W, where O_i^B and O_i^W are the best and worst targets of $O_i(x) : i = 1, 2, 3$.

With reference to the interval target $[O_i^W, O_i^B]$, we construct the normalized functions of the three objectives as:

$$\mu_i = (O_i(x) - O_i^W) \Big/ (O_i^B - O_i^W), \text{ where } : i = 1, 2, 3. \qquad \ldots\ldots..(2)$$

Step-2 *(Determination of highest common attainment):* As all three objectives are desired almost at the same level of importance, we find out the maximum common attainment level λ for all their corresponding normalized functions by aggregating them with "Min" operator. Hence, we reduce the MO01LP model (1) to an equivalent mixed 0-1 linear programming (M01LP) model as:

Max λ

s. t. $\lambda \leq \mu_i$: i = 1, 2, 3. ……(3)

$$\mu_i = (O_i(x) - O_i^W) / (O_i^B - O_i^W)$$

$$A.X \leq B$$

$$B.X \geq d$$

where $X \in \{0, 1\}$ and λ ϵ [0, 1].

Let $\bar{x}$ be the optimum solution of the model (3) that results in the maximum value of $\lambda = \lambda^*$, which gives a compromise solution for the MO01LP model (1). At this point, the normalized value of all the three objectives attain their highest common value. However, $\bar{x}$ may not be efficient for the MO01LP model (1).

Step-3 *(Determination of supported efficient solution)*: Unlike in a multi-objective LP where every efficient solution is supported, there exists unsupported efficient frontier in multi-objective integer LP. The supported efficient solutions of the model (1) are optimal solutions of the weighted single objective model (Przybylski and Gandibleux, 2017)

$$Max \{ w_1.\mu_1 + w_2.\mu_2 + w_3.\mu_3 : w_i \in]0, 1[\}$$

S. t. $\mu_i = (O_i(x) - O_i^W) / (O_i^B - O_i^W)$, where : $i = 1, 2, 3.$

$$A.X \leq b$$

$$B.X \geq d$$

where $X \in \{0, 1\}$ and $\mu_1, \mu_2, \mu_3 \in [0, 1]$. …….. (4)

Hence, we push $\bar{x}$ obtained from the model (3) to the efficient frontier by a compensatory decision model:

$$Max \{ w_1.\mu_1 + w_2.\mu_2 + w_3.\mu_3 : w_i \in]0, 1[.$$

s. t. $\mu_i = (O_i(x) - O_i^W) / (O_i^B - O_i^W)$, where : $i = 1, 2, 3.$ …….. (5)

. $\mu_i \geq \lambda^*$

$$A.X \leq b$$

$$B.X \geq d$$

where $X \epsilon \{0, 1\}$ and $\mu_1, \mu_2, \mu_3 \epsilon [0, 1]$.

Considering $w_1 = w_2 = w_3 = \frac{1}{3}$, we get $\bar{x}^*$ as the optimal solution for the model (5) having the highest common attainment level in all the normalized objective functions.

Theorem 1: The optimal solution $\bar{x}^*$ is a supported efficient solution for the MO01LP model (1).
Proof: Model (5) has additional constraints $\mu_i \geq \lambda^*$ than model (4). Thus, the solution space of the model (5) is a subset of the solution space of the model (4). If $\bar{x}^*$ is a supported efficient solution for the model (1) with respect to the model (5) having $w_1 = w_2 = w_3 = \frac{1}{3}$, then $\bar{x}^*$ also becomes supported efficient for the same model with respect to the model (4) for some $w_i \epsilon]0, 1[: i = 1, 2, 3$.

Hence, $\bar{x}^*$ becomes a supported efficient solution for the MO01LP model (1) with maximum common attainment level in all three normalized objective functions. However, this method can also be extended to involve some trade-off between the objectives before choosing a suitable solution among the supported efficient solutions.

6. Analysis and Interpretation of Results:

The multi-objective 0-1 mixed linear programming algorithm is used for solving the marketing problem as defined in section 4. The final result depicts the specific type of products (saree) selected with its quality, body, border and characteristic design so as to target these products to specific consumer segments (consumer culture). Table 8 gives the final values of the objective functions. The selected variables with interpretation is given in table 9.

Table 8 Objective functions

	Maximum Value	Minimum Value	First Solution	Supported efficient solution
Demand	1022 lakhs[7]	237 lakhs	600 lakhs	813 lakhs
Cost	Rs.26070/-	Rs.3869/-	Rs.12948/-	Rs.19338/-,
Growth	1005 lakhs	212 lakhs	564 lakhs	790 lakhs

[7] 10 lakhs make one million

Table 9 Optimization results (chosen variables)[8]

Design Selection	Target segment	Cost (INR)	Demand (INR Lakhs.)	Growth (INR Lakhs.)
Silk –booty- animal, birds design -Pochampalli	Group 2	2000	55	50
Silk- booty- social events design- Sambalpuri	Group 1	1000	12	90
Silk -booty -social events design- Sambalpuri	Group 2	1000	32	88
Silk -wide stripes -animal, birds design -Pochampalli	Group 1	2725	10	98
Silk- wide stripes- animal, birds design -Sambalpuri	Group 1	1500	73	40
Silk- wide stripes- animal, birds design- Sambalpuri	Group 2	1500	62	31
Tasar –booty- animal, birds design -Pochampalli	Group 1	1428	80	70
Tasar –booty- animal, birds design- Pochampalli	Group 2	1428	63	36
Tasar –booty- animal, birds design -Sambalpuri	Group 1	1390	49	57
Tasar –booty- animal, birds design -Sambalpuri	Group 2	1390	94	68
Tasar -wide stripes -animal, birds design- Pochampalli	Group 2	857	87	23
Tasar -wide stripes- animal, birds design -Sambalpuri	Group 1	1400	43	39
Tasar -wide stripes -social events design -Pochampalli	Group 1	737	81	39
Tasar -wide stripes- social events design -Sambalpuri	Group 2	983	72	61

6.1 Validation of the final outcome

The outcome of optimization model was the selection of 14 new products for commercialization out of a total 32 new designs. Hence, these 14 new products have a superior probability of success. As our optimization model is proposed as a replacement for test marketing, we decided to validate the result at 2 levels.

[8] Tasar / silk- raw materials for making saree. Booty / wide stripes – types of body for the saree. Animal, birds design / social events design are types of imprints for the body of the saree. Sambalpuri / Pochampalli – overall design for the saree based on the names of the regions/ places

6.1.1 Study 1

The objective of study 1 is to ascertain the impact of new designs on the store performance. The underlying hypothesis is as follows:

H_1: The store type and stock being same / similar, the introduction of new products / new designs improves the store performance significantly.

For this study, we designed a natural experiment and determined the DiD (Difference in Difference) with stores (where same / similar products are sold) as the test units and sales as the store performance indicator (dependent variable). We chose 25 medium sized stores (1500–3000 square feet) across 5 cities where the new products from the study area are frequently sold and used them as the test group. We chose another set of 25 similar stores in the same cities who are not the customers for the new products from the study area. We chose a non-peak season (non-festival season) where new products are traditionally not introduced and chose the second set of the stores as the control group. We observed the performance (sales) of the 50 stores for a period of 6 months. After 2 months of the observation period, in the test group, all 32 new products were introduced (treatment). There was no new product introduction in the control group. We observed and compared the store performance for another 4 months.

The proposed relationship is represented in equation 6.

$$Y_{i,t_1} - Y_{i,t_2} = \delta + \gamma d_{i,t} + \epsilon_i, \ldots\ldots\ldots\ldots (6)$$

where

$Y_{i,t_1} - Y_{i,t_2} =$ difference between the repeated outcome measures for each observation

$d_{i,t} =$ treatment indicator at time t

$\gamma =$ treatment effect

$\delta =$ Constant i. e. the effect of time on all units

$\epsilon_i =$ error for i^{th} observation

The experimental design is a before-after with control group design where 25 retail stores from test group are observed for test group results (treatment 1) and the 25 control group are observed for control group

results (treatment 0). The dependent variables (sales) data is collected before as well as after the treatment and the difference in result is regressed against treatment indicator.

The model and the treatment effect are identified to be significant (P value = 0, Treatment effect =0. .110).

6.1.2 Study 2

The objective of study 2 is to compare the impact of the optimization model chosen new products (14) against the rest of the new products (18) on the store performance. The underlying hypothesis is as follows:

H_2: The store type and stock being same / similar, the optimization model chosen new products / new designs perform significantly better than the non-chosen ones.

For this study, we designed a natural experiment and determined the DiD (Difference in Difference) with stores (where same / similar products are sold) as the test units and SKU (stock keeping units) sales, turn over and ROI (return on investment) as the dependent variable. Here, the frame of reference for the SKUs is restricted to the new products design in the study area. We randomized 25 medium sized stores (1500–3000 square feet) across 5 cities where the new products from the study area are frequently sold and used them in the experimental design. We chose 10 stores each as the test group and control group, respectively. In the test group, only the 14 optimization model chosen were products were sold. In the control group, the rest of the 18 non-chosen new products were sold. The rest of the stock for the 20 stores was similar and comparable to each other. We observed the SKU performance for the 32 new products for a period of 6 months (2 months before the new product introduction and 4 months after the new product introduction). New product introduction is used as the treatment. We chose a non-peak season (non-festival season) where new products are traditionally not introduced as the study period.

The proposed relationship can also be represented in equation 6. The model and the treatment effect are identified to be significant (Table 10).

Table 10 Natural experiment results (Study 2)

	Sales		Turnover		ROI	
	P value	$\beta_{Treatment}$	*P* value	$\beta_{Treatment}$	*P* value	$\beta_{Treatment}$
Stores	.000	.110	.017	.044	.000	.085

Secondly, we advised the master weavers / cooperatives / societies in the handloom clusters (5 chosen) to commercialize the 32 designs in the market. We observed the results of the commercialization. The results of commercialization are given in table 11, which further support the validation of the model.

Table 11 Financial performance of the handloom products from test marketing and commercialization

Test market: TM Commercialization: C

	No. produced for each type	% sales test market (TM)	% sales (C)	Turnover period in days (TM)	Turnover period in days (C)	Repeat orders (TM)	Repeat orders (C)
Chosen 14	2000	90	75	15	27	90% of times	80% of times
Rest 18	2000	40	20	30	120	50% of times	30% of times

7. Conclusion

New product development and fruitful commercialization is one of the cornerstones of success in consumer business and more so in the unorganized sector. This study considered three major objectives. Firstly, improving the success rate of any NPD process by optimizing the test marketing step. Secondly, targeting an unorganized SME sector (viz. handloom) in an emerging economy for primary research and improvement of performance, hitherto not studied to the best of our knowledge. Thirdly, extending the application of an optimization method to a niche business scenario by adequate modification, algorithm development and appropriate validation. The first objective is achieved with systematic analysis of test marketing practices and development as well as implementation of alternative optimization based method for a more successful NPD process. The second objective is achieved by primary empirical research in the study area (handloom clusters in Odisha), understanding and appreciating the business model, its shortcomings, development of appropriate solution approach and showcasing the success of the improved procedure. The third objective is achieved through development of multi-objective 0-1 mixed linear programming model.

Through this research, we have envisioned a threefold contribution. The academic contribution consists of development, necessary modification and subsequent usage of an optimization method to the of a test marketing scenario in NPD. It also involves providing alternative scientific methods to improve the success of any NPD process. The managerial contribution consists of improving the business model for an unorganized sector in an emerging market and successfully demonstrating the feasibility of the said

business model. The social contribution involves studying a traditional yet often neglected sector in an emerging economy that contributes to the livelihood of millions, participating in their decision making process, suggesting feasibility of survival and most importantly, bringing the incumbent social as well as managerial issues to the forefront. Finally, scalability and ability for appropriate commercialization remains the prime advantage of this optimization model and solution procedure.

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