An AHP integrated QFD approach for mitigating upstream supply chain barriers: A study on Ready-Made Garment (RMG) industry of Bangladesh

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ABSTRACT

The complexity of supply chain network and its activities are increasing gradually with the globalization and increased outsourcing by the companies. The increased complexities create different problems and barriers in supply chain operations which need to be mitigated to remain competitive. The barriers adversely affect both revenue and cost of the whole supply chain. A number of research works have been conducted on supply chain barriers and complexities but research on upstream supply chain barrier is not substantial in number especially in the context of RMG industry. Identifying upstream supply chain barriers and finding corresponding mitigation approach in the context of RMG industry is even unexplored. Therefore, this study aims at identifying upstream supply chain barriers in RMG industry of Bangladesh and corresponding mitigation design requirements by applying an AHP integrated QFD approach. Study finds that upstream supply barrier specifically longer lead time is the most important barrier in comparison to five other barriers. Corresponding to the upstream supply barrier efficient planning, commitment to meet on time delivery and quick response are highly important mitigation design requirements.

Keywords: Upstream supply chain, barrier, mitigation, AHP, QFD, HOS.

1. INTRODUCTION

In a supply chain upstream and downstream chain members- the suppliers, focal companies and customers- are linked by information, material and capital flows to produce values and to serve the customers (Seuring and Muller, 2008). Many companies manage their supply chain effectively and efficiently in an effort to increase competitiveness, customer satisfaction, and profit. The complexity of supply chain network and its activities are increasing gradually with the globalization and increased outsourcing by the companies. As a result supply chains are facing numerous obstacles in different stages of procurement, processing and distribution. For example, transportation delays, port stoppages, accidents and natural disasters, poor communication, spare part shortages, quality issues, operational issues are common problems in the supply chains often exposed to (Blackhurst et al., 2005). These increased problems and barriers need to be mitigated to remain competitive and sustainable (Christopher and Lee, 2004). Otherwise, the consequences will be the discontinuity of supply chain operations which adversely affect both revenue and cost of the whole chain (Ponomarov and Holcomb, 2009). The consequences are even more intensive in complex and longer supply chains. Like some other complex supply chain, the global RMG supply chain also consists of a number of critical activities. There is multiplicity of numerous barriers in the upstream and downstream RMG supply chain. Barriers, such as, lack of co-ordination (Cao et al., 2008), maximum lead time to process an order (Habib, 2009; Nuruzzaman, 2008; Nuruzzaman, 2007; Kabir, 2007; Knutsen, 2004), lack of backward linkages industries (Habib, 2009; Nuruzzaman et al., 2010), bureaucratic behaviour (Quddus, 2001; Quddus and Rashid., 1999), compliance of social and environmental factors (Haider, 2007) have been focused in different research works of RMG industry. It is very essential to make the RMG industry more efficient by mitigating those barriers in an effective manner. But research work on mitigating barriers in RMG supply chain is very rare.

The dearth of research on mitigation of barriers in RMG supply chain has motivated the researchers to conduct the underlying research and address the following research questions- (i) What are the upstream supply chain barriers? and (ii) What are the mitigating approaches to those barriers? In an attempt to find solutions to the research problem an AHP integrated QFD approach has been applied in this research. QFD approach which is designed to identify specific requirements of customers and corresponding design requirements (Mukherjee, 2011) is also used and considered as one of the effective tools in the field of supply chain management. For example, it has been used by Pujawan and Geraldin, (2009) for identifying risk agents and designing mitigation approach to prevent the risks. With reference to this it is also relevant to apply QFD in identifying supply chain barriers and developing mitigation approach corresponding to those barriers in this research.

2. LITERATURE REVIEW

2.1 Supply chain

Supply chain encompasses all activities associated with the flow and transformation of goods from the raw materials stage through to the end user, as well as the associated information flows (Nuruzzaman et al., 2010) . In the supply chain different network members are linked with a view to the exchange of material and information. Supply Chain Management is concerned with the effectiveness of dealing with final customer demand by the parties engaged in the provision of the product as a whole (Cooper et al., 1997). Cooper and Ellram (1993) have defined SCM as, "an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer". Supply chain functions involve planning, sourcing, making, delivery and return. Different supply chain members in different tiers are involved in these supply chain functions. Among those some are engaged with producing and supplying raw material, transportation of the material and processing of the raw material or semi-finished material. Some are involved with producing finished goods and some are distributing and transportation of the finished goods. The functions ranging from procurement, inbound transportation, warehousing to processing of semi-finished and finished goods are upstream supply functions and the functions from processing of finished goods to distribution of finished goods termed as downstream supply chain functions. In settling the supply chain functions the supply chain members face different complexities and barriers either upstream or downstream.

2.2 Supply chain barriers

Supply chains are often exposed to different barriers and complexities in discharging the chain functions. A number of current business trends are responsible for growing complexities in supply chains which are: more intensity to the use of outsourcing of manufacturing and R&D to suppliers, increased globalization of supply chains, consolidation of supplier base, demand for more integrated processes between companies, reduced buffers with respect to inventory and lead time, increased demand for on-time deliveries and shorter lead times, shorter product life cycles and compressed time-to-market, capacity limitation of key components (Blackhurst et al., 2005; Trent and Monczka, 2002; Norman K. Denzin et al., 2000). The complexities and barriers in the supply chain may take different forms, such as, delay during transportation, port stoppages, frequent occurrence of natural disasters, weak communication, supply shortages, Demand volatility, quality problem, operational issues and terrorism are few among the lot (Kleindorfer and Saad, 2005; Blackhurst et al., 2005). Kleindorfer and Saad (2005)classified three main categories of supply chain disruption: Firstly, operational disruption which envelops equipment malfunctions and systemic failures, abrupt discontinuity of supply, bankruptcy, fraud, or labor strikes; secondly, natural hazards which include earthquakes, hurricanes, storms; and thirdly, terrorism or political instability. In this way a number of researchers such as Christopher and Peck (2004), Sheffi (2005), Wu et al. (2007), Pettit et al., (2011) discuss a wide range of disruptions that create barriers in supply chain operations.

2.3 Upstream supply chain barriers

Though there are substantial research contribution in the field of supply chain disruptions and barriers but specific research work on upstream supply chain barriers is not much mentionable. Quaddus and Didi (2005) have defined that perceived or likely constraints are the barriers. In the upstream supply chain those things are barriers which are creating constraints in the chain. Some of the upstream supply chain barriers are weaknesses such as poor infrastructures, long lead time, lack of commitment and trust, forced to reduce price, weak bargaining power, threats of choosing alternative suppliers from another country, lack of cooperation etc. are discussed by Wu et al., (2004) ; Zhao, et al., (2008); Pettit et al., (2011) and Nuruzzaman, (2001; 2010). Halder and Kim (2012), Islam et al (2012) and Ahmed (2009) have mentioned various types of barriers faced by the manufacturers and also considered as upstream barriers. In the literature of international business some studies have been conducted about the influence and barriers of different factors such as; bureaucracy, political risk, country risk in the international supply chain which are also relevant to upstream supply chain risk.

2.4 RMG supply chain

Few research works (De Brito et al., 2008; Christopher and Lee, 2004; Knutsen, 2004; Lam and Zhao, 1998) have been made to investigate supply chain (SC) in clothing or RMG industry. Most of these studies primarily dealt with the applications of ICT and development of relationship within the members of SC.

Most of the studies in textile sector focused on integration and relationship management for building partnerships between different parties of the chain and synchronizing activities throughout the chain (Chandra, 1997; Zhao et al., 2008). In the literature (Wong 1999; Bowen, 2000; Rungtusanatham, 2003; Cao et al., 2008) coordination, collaborative relationships and partnerships are described as preferential situations and as beneficial to all parties involved in the chain. Some studies (Chandra and Sameer, 2000; Nuruzzaman, 2007; Nuruzzaman et al., 2010; Buxey, 2005) have recommended various technological solutions like applications of IT, ICT, E-Commerce, EDI implementation etc. to improve competitive advantage and performance through lead time reduction and supply chain (SC) collaboration. In many studies (Chandra and Sameer, 2000; Mason - Jones and Towill, 1999) emphasis has been given on information enriched SC i.e. Quick Response (QR) and Accurate Response (AR) in the textile SC. Some studies have also recommended JIT delivery system, Production planning period compression, lean and agile approaches that effectively synchronize the manufacturing process in order to reduce cycle time and lead time (Christopher and Lee, 2004; Ferdousi and Ahmed, 2009; Mason - Jones and Towill, 1999).

2.5 Quality function deployment (QFD)

QFD is an effective tool to identify and resolve the issues involved in products, processes, services, and strategies (González et al., 2004). It is a systematic process used by cross-functional teams and was laid out in the late 1960s to early 1970s in Japan by Akao (1990). The benefits of this model have been emphasized by various researchers, such as, Sullivan (1986), Hauser and Clausing (1988), Zairi and Youssef (1995), Chan and Wu (2002), and Terninko (1995). Although the popular application fields of QFD are product development, quality management and customer needs analysis, but the utilisation of QFD method has spread out to other manufacturing fields in time (Chan and Wu, 2002). Recently, companies are successfully using QFD as a powerful tool that addresses strategic and operational decisions in businesses (Mehrjerdi, 2010). In using QFD, organisation will be able to achieve reduction in the number of design changes, lower start-up costs, shorter design cycles, fewer warranty claims, improved internal communications, and increased sales (Griffin and Hauser, 1993). Because of its wide applicability QFD is used in various fields such as determining customer needs (Stratton, 1989), developing priorities (Han et al., 1998), formulating annual policies (Philips et al., 1994), manufacturing strategies (Crowe and Cheng, 1996; Jugulum and Sefik, 1998), benchmarking (Pfohl and Ester, 1999), and environmental decision making (Berglund, 1993). Chan and Wu (2002) and Mehrjerdi (2010) provide a long list of areas where QFD has been applied successfully. The use of QFD is also extended to logistics and supply chain management. Bottani and Rizzi (2006) used QFD to show the impact of logistics in customer service improvement. Bevilacqua et al. (2006) used QFD for supplier selection process. Sohn and Choi (2001) used the QFD model to systematically relate customer requirements with design requirements in each supply chain of product development. Pujawan and Geraldin (2009) used QFD for supply chain risk management. Therefore, the QFD model can also be used to identify barriers in upstream supply chain and to design mitigation approach corresponding to those.

In QFD modelling, 'customer requirements' or existing problem of organizations are referred as WHATs and 'how to fulfil the customer's requirements' or organizational problems are referred as HOWs (See Figure 1). The process of using appropriate HOWs to meet the given WHATs is represented as a matrix. Different users build different QFD models involving different elements but the most simple and widely used QFD model contains at least the requirements/problems (WHATs) and their relative importance, technical measures or design requirements (HOWs) and their relationships with the WHATs, and the importance ratings of the HOWs. It is also called the relationship Matrix: relationships between WHATs and HOWs (strong, medium or weak). Along with these steps the interrelationships among the design requirements (Roof Matrix) and Competitive Assessment (assessment of customer satisfaction with the attributes of the competitors') are also used (Mukherjee, 2011).

3. METHODOLOGY

Research paradigm can be classified as two types: positivist and interpretivist (Onwuegbuzie and Leech, 2005). In positivist research reality is independent from the researcher and the research is objective oriented (Johnson and Onwuegbuzie, 2004; Smith, 1983) and data collection, analyses are value-free rather than subjective interpretation (Krauss, 2005). Further, positivist paradigm is associated with the quantitative research based on specific research question and hypotheses testing (Johnson and Onwuegbuzie, 2004; Creswell, 2003). On the other hand, interpretivist paradigm relies on the qualitative method and there is subjective interpretation of researcher because the advocates of this paradigm believe that the researcher should have interaction and subjective involvement with issues being researched (Creswell, 2003). This research approach complies with the framework of positivist paradigm as the research is very much objective oriented. This research approach has the objective to identify critical sustainability barriers and corresponding mitigation requirements using AHP integrated QFD. QFD has been used frequently in object oriented research.

For QFD analysis of this paper the following steps are followed:

Step 1: Identification of requirements or problems of organizations that are termed as WHATs;

Step 2: Relative importance ratings of WHATs are determined;

Step 3: Design requirements (HOWs) are generated;

Step 4: Relationships between WHATs and HOWs are determined;

Step 5: Based on the rankings of weights of HOWs the design requirements are selected.

Step 6: Relationships between HOWs are determined

Data have been collected from the supply chain managers of two RMG manufacturers and one supplier. The respondents have been asked about the barriers they are facing during procurement and processing stage. Then they are asked to classify those barriers. After classification they are asked to find priorities among the factors and then among the sub factors by using AHP method. After identification of barriers (WHATs) and their importance as mentioned as step 1 and step 2, Design requirements (HOWs) are generated which is step-3.

In step 4, the relationship between supply chain barriers and corresponding mitigation design requirement (DR) is described as *Strong, Moderate, Little,* or *No* relationship which are later replaced by weights (e.g. 9, 3, 1, 0) to give the relationship values needed to make the design requirement importance weight calculations. These weights are used to represent the degree of importance attributed to the relationship. Thus, as shown in Table 1, the importance weight of each design requirement can be determined by the following equation:

$D_w = \sum_{i=1}^{n} A_i R_{iw} \qquad \forall_w, \; w = 1, \dots \dots, m$ .... (1)

Where,

D_w = importance weight of the ***w***th design requirement;

A_i = importance weight of the ***i***th supply side barriers;

R_{iw} = relationship value between the ***i***th barriers and ***w*** th design requirement;

m = number of design requirements;

n = number of supply side barriers.

In Table 3, inbound supply barriers, institutional and infrastructural barriers, suppliers' barrier, management inefficiency barrier, workers inefficiency barrier and incidental barriers are considered as upstream supply chain barriers. The importance weight of the barriers is calculated using AHP by discussion with the executive of one readymade garments manufacturer and one supplier. According to the QFD matrix the absolute importance of the barriers can be determined by the following equation:

$AI_i = \sum_{i=1}^{n} R_i D_w \qquad \forall_w, \; w = 1, \dots \dots, m$ .... (2)

Where,

AI_i = absolute importance of the ***i***th barrier (VR_i);

R_i = importance weight of the ***i***th barrier;

D_w = importance weight of the ***w***th capability design requirement;

Therefore, the absolute importance for the 1st inbound supply barrier (BR_{i1}) will be:

$AI_{i1}^{IB} = R_{i1} D_{w1} + R_{i1} D_{w2} + \dots\dots + R_{i1} D_{wm}$

Thus, the relative importance of the 1st inbound supply barrier (BR_{i1}) will be:

$RI_{i1}^{IB} = \frac{AI_{i1}}{\sum_{i=1}^{n} AI_i}$ .... (3)

Where,

RI_{i1}^{IB} = relative importance of the 1st inbound supply barrier (BR_{i1});

AI_{i1}^{IB} = absolute importance of the 1st inbound supply barrier (BR_{i1});

Similarly, the absolute importance and the relative importance of all other barriers (IBs, INLs, SBs, MBs, WBs and ICs) can be determined by following the Equations (2) and (3). Now, the absolute value for the first design requirements (DR_1) will be:

$$AI_{d1} = R_{i1}D_{w1} + R_{i2}D_{w1} + \ldots\ldots + R_{in}D_{w1}$$

In the same way, the relative importance of the 1st design requirement can be determined by the following equation:

$$RI_{d1} = \frac{AI_{d1}}{\sum_{d=1}^{n} AI_d} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

RI_{d1} = relative importance of the 1st design requirement (DR_1);

AI_{d1} = Absolute importance of the 1st design requirement (DR_1);

If we assume that there are n total barriers which include n_1 inbound supply barriers, n_2 institutional and infrastructural barriers,n_3 suppliers' barriers and n_4 Management inefficiency barriers, then,

$$n_2 = n - (n_1 + n_3 + n_4)$$

$$n_3 = n - (n_1 + n_{2+n_4})$$

Again, if we consider $\mathrm{w_{IB}}, \mathrm{w_{INL}}, \mathrm{w_{SB}}, \mathrm{w_{MB}}, \mathrm{w_{WB}}$ and $\mathrm{w_{ICB}}$ as the weights of the inbound supply barriers (IBs), institutional and infrastructural barriers (INLs), suppliers barriers (SBs) decided by the decision makers respectively, then,

$$\mathrm{w_{IB}} + \mathrm{w_{INL}} + \mathrm{w_{SB}} + \mathrm{w_{MB}} + \mathrm{w_{WB}} + \mathrm{w_{ICB}} = 1$$

Therefore, the relative importance can be determined as follows:

$$RI_i^{BR} = w_{IB}RI_i^{IB} \qquad i = 1,2, \ldots\ldots., n_1$$

$$RI_i^{BR} = w_{INL}RI_i^{INL} \qquad i = n_1 + 1, n_1 + 2, \ldots\ldots., n_2$$

$$RI_i^{BR} = w_{SB}RI_i^{SB} \qquad i = n_2 + 1, n_2 + 2, \ldots\ldots., n3$$

$$RI_i^{BR} = w_{MB}RI_i^{MB} \qquad i = n_3 + 1, n_3 + 2, \ldots\ldots., ns$$

Now if we assume that there are n number of barriers and for them we need m number of design requirements then the rating R_{qt} between each pair of the q^{th} inbound supply barriers (IBs) and the t^{th} design requirements (DR_t) is acquired from a teamwork (Özgener, 2003; Wang and Hong, 2007) with the weighting value of 0-1-3-9 to represent no, weak, moderate, or strong relationship. To allow the possible inter-dependence among the design requirements let assume δ_{tu} denote the correlation between DR_t and DR_u. So, by adapting Wasserman (1993) a normalised R_{qt} can be defined as follows:

$$R_{qu}^{norm} = \frac{\sum_{t=1}^{m} R_{qt}\delta_{tu}}{\sum_{u=1}^{m}\sum_{t=1}^{m} R_{qt}\delta_{tu}} \quad \text{..............} \ (5)$$

$$where, \quad q = 1 \dots \dots \dots n$$

$$u = 1 \dots \dots \dots m$$

Therefore, by integrating R_{qu}^{norm} with RI_i^{VR} the overall importance weights of the design requirements can be determined as follows:

$$AI_u^{DR} = \sum_{i=1}^{n} RI_i^{VR} R_{qu}^{norm} \quad \text{..............} \ (6)$$

$$where, \quad u = 1 \dots \dots m$$

$$RI_u^{DR} = \frac{AI_u^{DR}}{\sum_{u=1}^{m} AI_u^{DR}} \quad \text{..........................} \ (7)$$

$$where, \quad u = 1 \dots \dots m$$

The initial absolute importance and the relative importance of all other design requirements can be determined by following the Equation (1) and (4). Based on the example of inbound supply barriers (barriers) weights in Equation (2) and (3), and Equation (5) we can determine the normalised ratings of supply side barriers and design requirements. Then by integrating the normalised ratings of supply side barriers and design requirements and the relative importance weight of the barriers we can define final absolute importance weight and relative importance weight of the design requirements as shown in Equation (6) and (7). The trade-offs among the selected design requirements are identified based on whether improving one design requirement have a positive, negative, and/or no effect on other design requirements.

4. ILLUSTRATIVE EMPIRICAL STUDY

In this section, we provide a case study based on the information gathered about ready-made garments (RMG) industry of Bangladesh. Bangladesh is one of the leading exporters of RMG in the world. RMG industry is an economic propeller of Bangladesh and accounts for 76% of total export earnings and over 2.5 million direct employments. Because of enormous economic importance in the economy of Bangladesh, smooth operation in RMG supply chain is necessary. RMG supply chain is facing myriads obstacles at different phases. Few research works have been done about the barriers and complexities of RMG supply chain. For example in the studies of (Habib, 2009; Nuruzzaman, 2008; Nuruzzaman et al., 2010; Joarder et al., 2010; Halder and Kim, 2012; Khandker, 2010; Quddus and Rashid., 1999; Quddus, 2001) it have been mentioned that, import dependency, lack of backward linkage industry, longer lead time, unfavourable bureaucratic behaviour, high cost of financing, infrastructure problem, utility problem, suppliers relation, on time supply, lack of consciousness and sincerity, production planning, shortage of skilled labour, low productivity, illiteracy of workers, political disturbance, natural disaster, management inefficiency etc. often create barriers in RMG supply chain function. In those research works just some recommendations were made to mitigate those barriers but no specific empirical research works have been done about the upstream supply chain barriers and how to mitigate those barriers.

In this circumstance identification and prioritization of barriers as well as mitigation of those barriers is very important for the sustainability of the RMG supply chain in Bangladesh. The following sections enumerate the case study analysis and discussion by applying an AHP-integrated QFD approach. Following the methodology section, the QFD process in this case study starts with Identification of upstream supply chain barriers (WHATs) and their weights. Subsequently, discusses identification of mitigation of the barriers (HOWs) and so on.

4.1 Identification of barriers (WHATs):

As per the opinion of the decision makers of case companies following barriers have been identified:

4.1.1 Inbound supply barriers

(i) Raw material price fluctuation (.045); (ii) Import dependence (.135); (iii) Lack of backward linkage (.238) (.232); and (iv) Longer lead time (.582) (.522). (See Figure 2)

4.1.2 Institutional and infrastructural barriers

(i) Unfavourable bureaucratic behaviour (documentation, Banking procedure, port and custom formalities) (.114); (ii) High cost of financing (bank interest) (.044); (iii) Infrastructure problem (port congestion, poor logistics in port, poor road network and transportation) (.255); and (iv) Utility problem (.588). (See Figure 3)

4.1.3 Suppliers' barriers

(i) Bankruptcy and loss of key supplier (.064); (ii) Supplier relation (.256); (iii) Problem of on time supply by supplier (.546); and (iv) Defect in supplied material (.133). (See Figure 4)

4.1.4 Management inefficiency barriers

(i) Lack of sourcing skill of managers (.049); (ii) Lack of consciousness and sincerity regarding compliance of social and environmental factors (.481); (iii) Production planning problem (.320); and (iv) Forecasting and inventory management problem (.150). (See Figure 5)

4.1.5 Production workers inefficiency barriers

(i) Shortage of skilled labour (.481); (ii) Low productivity of workers (.325); (iii) Switching and absenteeism of workers (.088); and (iv) Illiteracy of workers and supervisors (.106). (See Figure 6)

4.1.6 Incidental barriers

(i) Production lockout and sabotage (.263); (ii) Accident and damage in plant (.079): (iii) Political disturbance (.659); and (iv) Natural disaster (.130). (See Figure 7)

4.2 Supply side barriers

(i) Inbound supply barrier; (ii) Institutional support barrier; (iii) Suppliers' barrier; (iv) Management inefficiency barrier; (v) Workers' inefficiency barrier; and (vi) Incidental barriers.
(See Figure 8)

4.3 Identification of mitigation techniques or design characteristics (HOWs):

After identification of barriers the following mitigation approaches have been explored (See Table 3):

(i) Forecasting and preparedness (F&P); (ii) Backup utility (BU); (iii) Maintaining good relation with Stakeholders (SR) (Relation with supplier, bureaucrats, employees); (iv) Developing backward linkages (BL); (v) Efficient planning (EP); (vi) Management consciousness toward social and environment issues (MCSE); (vii) Training and development (T&D); (viii) Commitment to meet delivery lead time (CDT); (ix) Building loyalty and devotedness of employees and supply chain partners (L&D); (x) Communication and information sharing with supply chain partners (RSCP); and (xi) Quick response (QR).

5. DISCUSSION AND FUTURE RESEARCH DIRECTION

Based on the interview with the supply chain manager of two RMG manufacturers and a supplier twenty five barriers have been identified. Then, by discussion with them total barriers have been categorised to six types namely as inbound supply barriers (IBs), Upstream institutional and infrastructural barriers (INLs); supplier's barriers (SBs); producers inefficiency barriers (MBs); Workers inefficiency barriers (WBs); and Upstream incidental barriers (ICs). After classification of the barriers, respondents have been asked to compare among barriers with in each category to determine importance of barriers. Among the barriers the two most prioritized barriers in each category of barriers have been included and in this way twelve barriers have been selected. Subsequently, barriers that have low importance in AHP importance rating have not been considered for barrier mitigation design requirement. The AHP weights of each category of barriers are shown in figure: 2,3,4,5,6, and 7. From these figures it is revealed that Longer lead time, utility problem, problem of on time supply, non-compliance of social and environmental issues, shortage of skilled workers, and political disturbances are the highest rated barriers with in the category of as inbound supply barriers (IBs), institutional and infrastructural barriers (INLs); supplier's barriers SBs; management inefficiency barriers (MBs); Workers inefficiency barriers (WBs); and incidental barriers (ICs) respectively. After, categorization and prioritization of barrier within the category another importance weighting has been carried out between the broad categories which is shown in figure: 8. It is evident from figure:8 that the most important barrier is inbound supply barrier (.398) followed by institutional and infrastructural support barrier (.238) and subsequently others.

From the QFD analysis it can be enumerated that corresponding to the most important inbound supply barrier (longer lead time) the important design requirements are efficient planning and commitment to deliver on time. For the barrier of utility supply the most important mitigation requirement is keeping back up power support. To mitigate the suppliers' barriers specifically, the problem of on time supply developing backward linkage facilities is important so that manufacturers get quick supply from backward linked facilities. Regarding the barrier related to non-compliance of social and environmental issues the most important mitigation approach is developing management consciousness. It is also evident that to mitigate the barrier of shortage of skilled workers the effective way out is training and development of workers. Similarly to mitigate incidental barrier important technique is forecasting and preparedness, information sharing with supply chain partners and quick response. Such techniques will help them to assort material from sources in advance otherwise procurement will be delayed due to strike and other political disturbances.

Developing and improving the upstream supply chain mitigation design requirements as shown in House of Barrier Mitigation (HoBM) model (Table 2 and Table 3) will help to accelerate the procurement and processing performance. Moreover, the roof matrix in the HoBM shows that there is a very strong relation between forecasting & preparedness and quick response. The relation between stakeholder relation and commitment to meet on time delivery is also very strong. It is notable that quick response is related with almost all design requirements and has very strong relation with Forecasting and preparedness, developing backward linkage facility, efficient planning, and commitment to meet on time delivery. Further, these barrier mitigation tools have high relation with most important upstream supply barrier of longer lead time. Therefore, the managers of RMG supply chain shall keep keen attention for quick response.

Developing and improving these design requirements will help to combat upstream barriers in the RMG supply chain and assist in building competitive advantage. However, how much cost and investment are involved in building these capabilities is to be analysed in the further research. It will be interesting if the downstream supply chain barriers and corresponding mitigation requirements are identified. Along with this, the cost and investment involvement in building these capabilities may be considered in further research.

6. CONCLUSION

The significance of this study can be seen as manifold. First, it identifies the upstream supply chain barriers of the RMG industry. Second, it suggests corresponding design requirements to mitigate those barriers. Third, it identifies the relationship among the mitigation techniques for strategic choice of the management. Finally, it has an indication to conduct future research to explore barriers and corresponding mitigation approach for downstream supply chain. Based on the opinion of the supply chain managers of the case companies an illustrative empirical study has been drawn. The study identifies twenty five upstream supply chain barriers which, later on narrowed down to twelve most important barriers. As many as eleven barrier mitigation design requirements have been identified during the interview with respondents. It is found that the most important upstream supply chain barrier is longer lead time and corresponding to it important mitigation requirement is efficient planning, commitment to meet on time delivery and quick response. Further, quick response is almost related with most of the barrier mitigation tools. Hence, the RMG supply chain managers need to pay attention to quick response to maintain on time delivery and to gain buyers satisfaction.

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FIGURES and TABLES:

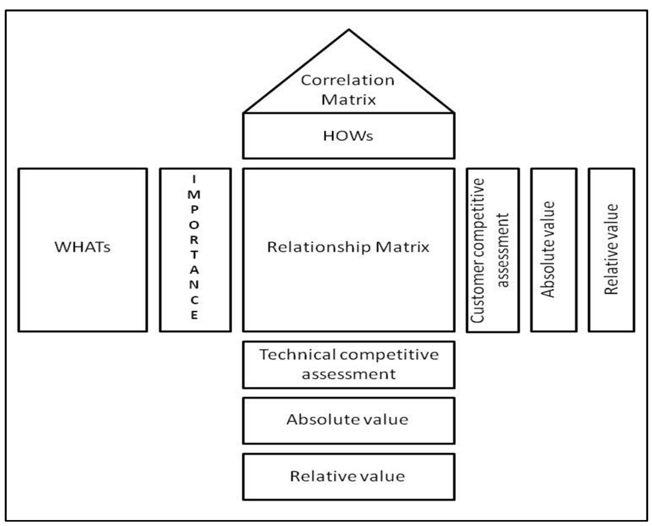


Figure 1: QFD model

Figure 2: Inbound supply barriers

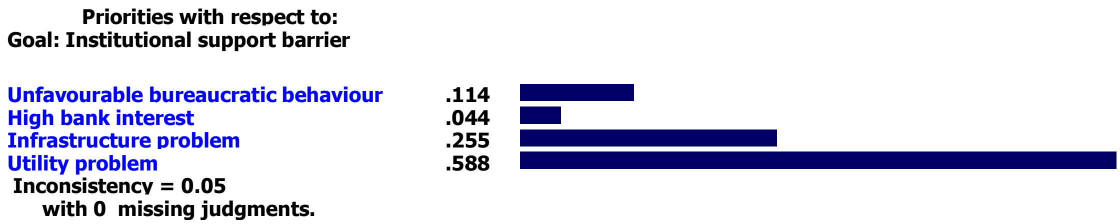


Figure 3: Institutional and infrastructural barriers

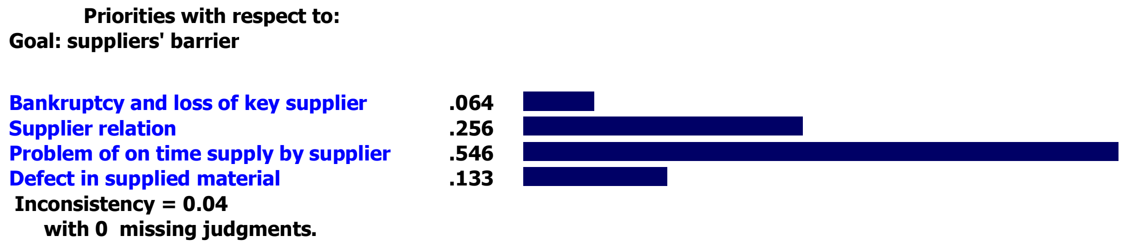


Figure 4: Suppliers' barriers

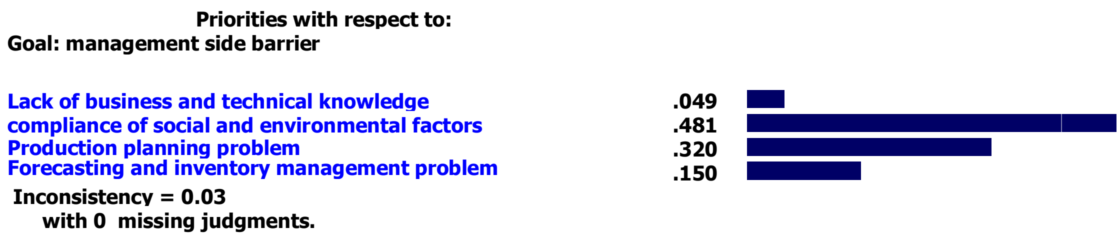


Figure 5: Management inefficiency barriers

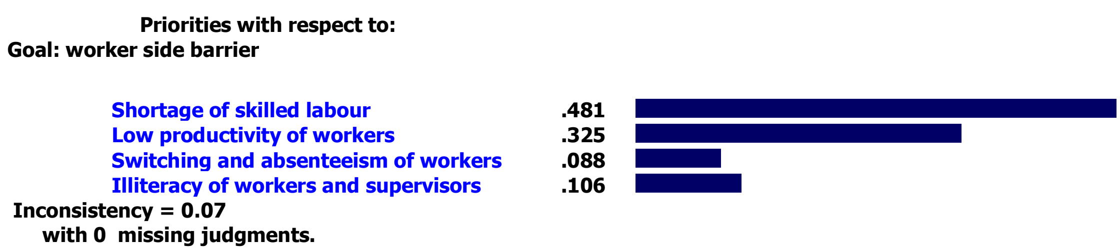


Figure 6: Production workers inefficiency barriers

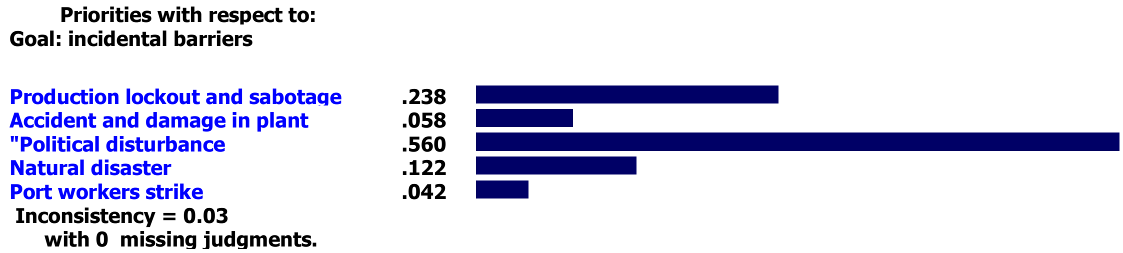


Figure 7: Incidental barriers

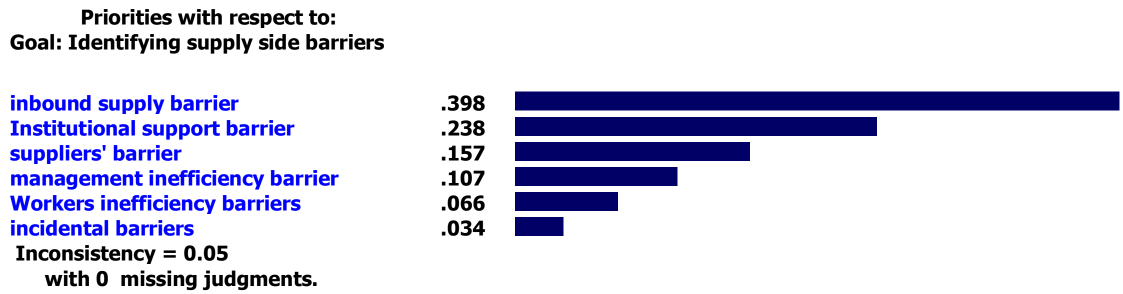
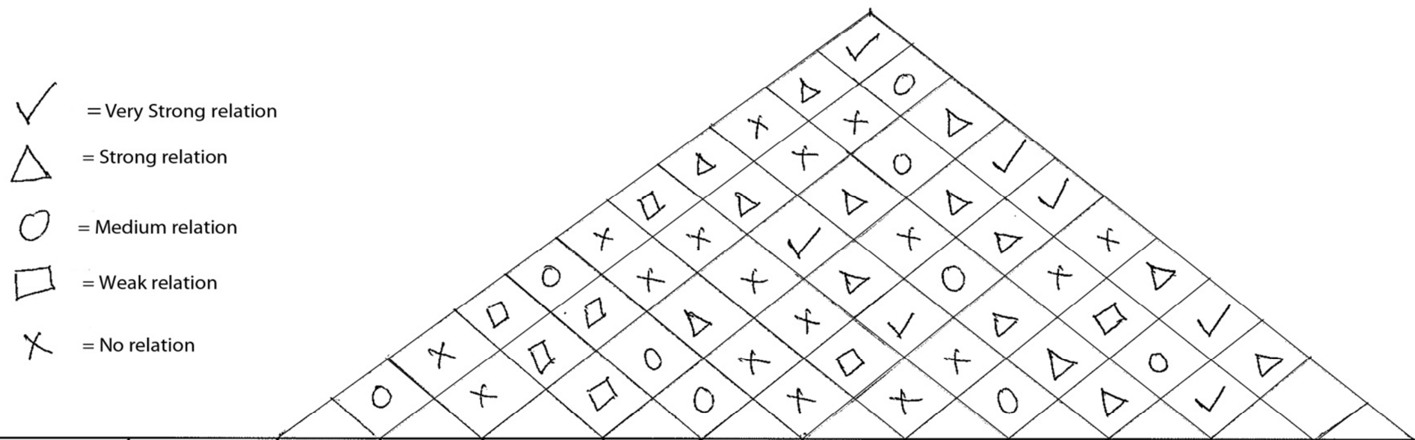


Figure 8: Supply side barriers

Supply chain barriers		DR_1	DR_2	.....	DR_m	A. I.	R. I.
IBs	BR_{i1}	$R_{i1}D_{w1}$	$R_{i1}D_{w2}$	.....	$R_{i1}D_{wm}$	AI_{i1}	RI_{i1}
	BR_{i2}	$R_{i2}D_{w1}$	$R_{i2}D_{w2}$	.....	$R_{i2}D_{wm}$	AI_{i2}	RI_{i2}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	BR_{in}	$R_{in}D_{w1}$	$R_{in}D_{w2}$	.....	$R_{in}D_{wm}$	AI_{in}	RI_{in}
INLs	BR_{j1}	$R_{j1}D_{w1}$	$R_{j1}D_{w2}$	.....	$R_{j1}D_{wm}$	AI_{j1}	RI_{j1}
	BR_{j2}	$R_{j2}D_{w1}$	$R_{j2}D_{w2}$	.....	$R_{j2}D_{wm}$	AI_{j2}	RI_{j2}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	BR_{jn}	$R_{jn}D_{w1}$	$R_{jn}D_{w2}$	.....	$R_{jn}D_{wm}$	AI_{jn}	RI_{jn}
SBs	BR_{k1}	$R_{k1}D_{w1}$	$R_{k1}D_{w2}$	.....	$R_{k1}D_{wm}$	AI_{k1}	RI_{k1}
	BR_{k2}	$R_{k2}D_{w1}$	$R_{k2}D_{w2}$	.....	$R_{k2}D_{wm}$	AI_{k2}	RI_{k2}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	BR_{kn}	$R_{kn}D_{w1}$	$R_{kn}D_{w2}$	.....	$R_{kn}D_{wm}$	AI_{kn}	RI_{kn}
MBs	BR_{L1}	$R_{L1}D_{w1}$	$R_{L1}D_{w2}$	.....	$R_{L1}D_{wm}$	AI_{L1}	RI_{L1}
	BR_{L2}	$R_{L2}D_{w1}$	$R_{L2}D_{w2}$	.....	$R_{L2}D_{wm}$	AI_{L2}	RI_{L2}
	…	…	…	.....	.....	.....	.....
	BR_{Ln}	$R_{Ln}D_{w1}$	$R_{Ln}D_{w2}$		$R_{Ln}D_{wn}$	AI_{Ln}	RI_{Ln}
WBs	…….	……..	………	……..	………	…….	……
ICs	……..	……..	………	….....	……..	…….	……
A. I.		AI_{d1}	AI_{d2}	….	AI_{dm}		
R. I.		RI_{d1}	RI_{d2}	….	RI_{dm}		

Note: A.I. = Absolute importance; R.I.= Relative importance; DR= Design requirements; IBs= Inbound supply barriers ; INLs= institutional and infrastructural barriers; SBs = suppliers barriers; MBs = Management inefficiency barriers; WBs= Workers inefficiency barriers; ICs= Incidental barriers.

Table 1: QFD matrix



		F&P	BU	SR	BL	EP	MCSE	T&D	CDT	L&D	RSCP	QR	A.I
Inbound supply barriers	Longer lead time	0.7	0.23084	1.15818	0.20696	1.61986	0	0.6965	1.61986	1.15818	1.15818	1.15818	9.70674
	Lack of backward linkage	0.284172	0	0	0.85172	0.09552	0	0	0	0	0	0.28258	1.513992
Institutional & infrastructural barrier	Utility problem	0.69972	1.25902	0	0	0.14042	0	0	0	0	0	0	2.09916
	Infrastructure problem	0.30464	0	0.06069	0.23324	0.18326	0	0	0.06069	0	0.06069	0.23205	1.13526
Suppliers' barrier	Problem of on time supply	0.59974	0.42861	0.59974	0.77087	0.42861	0	0.25748	0.59974	0.42861	0.42861	0.25748	4.79949
	Supplier relation	0	0	0.3611	0.20096	0.040192	0	0	0.20096	0.28103	0.3611	0.20096	1.646302
Management inefficiency	Non-compliance of social and environmental factors	0	0	0	0	0.25787	0.46331	0.05136	0.15408	0	0	0	0.92662
	Production planning problem	0.1712	0		0	0.30816	0	0.23968	0	0	0.10272	0.1712	0.99296
Workers inefficiency	Shortage of skilled labour	0.09504	0	0	0	0.09504	0.15906	4.329	0	0.09504	0	0	4.77318
	Low productivity of workers	0.06402	0	0	0	0.06402	0.10725	0.19338	0	0.06402	0	0	0.49269
Incidental barriers	Political disturbance	0.1343	0	0.05746	0	0.05746	0	0	0	0	0.09588	0.09588	0.44098
	lockout and sabotage	0.04046	0	0.04046	0	0.02414	0.07276	0	0.02414	0.07276	0.04046	0.04046	0.35564
A.I		3.093292	1.91847	2.27763	2.26375	3.314552	0.80238	5.7674	2.65947	2.09964	2.24764	2.43879	28.883014
R.I		0.107097272	0.066422085	0.078857075	0.078376516	0.11475783	0.027780342	0.199681377	0.092077302	0.072694629	0.077818748	0.084436825	

Table 2: House of Barrier Mitigation (HoBM)

		F&P	BU	SR	BL	EP	MCSE	T&D	CDT	L&D	RSCP	QR	A.I
Inbound supply barriers	Longer lead time	0.07211484	0.023781414	0.119317093	0.021321267	0.166879921	0	0.071754266	0.166879921	0.119317093	0.119317093	0.119317093	1
	Lack of backward linkage	0.187697161	0	0	0.56256572	0.063091483	0	0	0	0	0	0.186645636	1
Institutional & infrastructural barrier	Utility problem	0.333333333	0.599773243	0	0	0.066893424	0	0	0	0	0	0	1
	Infrastructure problem	0.268343816	0	0.053459119	0.205450734	0.161425577	0	0	0.053459119	0	0.053459119	0.204402516	1
Suppliers' barrier	Problem of on time supply	0.12495911	0.089303238	0.12495911	0.160614982	0.089303238	0	0.053647367	0.12495911	0.089303238	0.089303238	0.053647367	1
	Supplier relation	0	0	0.219340072	0.122067519	0.024413504	0	0	0.122067519	0.170703796	0.219340072	0.122067519	1
Management inefficiency	Non-compliance of social and environmental factors	0	0	0	0	0.278290993	0.5	0.055427252	0.166281755	0	0	0	1
	Production planning problem	0.172413793	0	0	0	0.310344828	0	0.24137931	0	0	0.103448276	0.172413793	1
Workers inefficiency	Shortage of skilled labour	0.019911254	0	0	0	0.019911254	0.033323696	0.906942541	0	0.019911254	0	0	1
	Low productivity of workers	0.129939719	0	0	0	0.129939719	0.217682518	0.392498326	0	0.129939719	0	0	1
Incidental barriers	Political disturbance	0.304548959	0	0.130300694	0	0.130300694	0	0	0	0	0.217424827	0.217424827	1
	lockout and sabotage	0.11376673	0	0.11376673	0	0.067877629	0.20458891	0	0.067877629	0.20458891	0.11376673	0.11376673	1
A.I		1.727028715	0.712857895	0.76114282	1.072020222	1.508672262	0.955595125	1.721649061	0.701525053	0.73376401	0.916059356	1.18968548	12
R.I		0.14391906	0.059404825	0.063428568	0.089335019	0.125722689	0.079632927	0.143470755	0.058460421	0.061147001	0.07633828	0.099140457	

Table 3: Normalised table of mitigations