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Exploring Performance Deficits in the Fish Feed Supply Chain of Bangladesh

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ABSTRACT

Fish farmers in Bangladesh have many issues with the performance of the feed supply chain. The study used the supply chain operations reference (SCOR) model to select the key operational stages of the supply chain and the measurement criteria. The analytical hierarchy process (AHP) prioritized the phases and criteria and developed the expected performance of the feed supply chain. By comparing the expected performance and the perceived current performance, we identified the performance gap in the feed supply chain. The transaction costs were calculated separately. The study found that high costs were the main reason for low performance in the feed supply chain. The reliability of the product quality was also a concerning issue in the chain. Compared to other actors in the chain, dealers are the low performers. The study suggests performance can be improved by developing direct channels between manufacturers and farmers, thereby omitting dealers and concentrating on local raw material production. The study also demonstrated that transaction costs play an important role in the performance of the supply chain. This study is the first to empirically examine this situation and is innovative in that its examination of the feed supply chain included transaction costs.

Keywords: *transaction costs, SCOR model, supply chain, efficiency, analytical hierarchy process*

1. INTRODUCTION

Bangladesh produced 4.27 million tons of fish in 2018 (FAO, 2020), and from 1984 to 2014 aquaculture production in Bangladesh increased sixteen-fold (Hernandez *et al*., 2017). The average annual growth in feed production in the commercial fish feed industry is 25–32% and it continues to grow (Mamun-Ur-Rashid *et al.,* 2013). Although it is expected that growth in the production of feed would lead to economies of scale resulting in lower costs, but the price of feed increased by 28% from 2010 to 2015 (Ahmed, 2015). With feed accounting for 82% of production costs at the farm level (Belton *et al*., 2011), that indicates the performance of the fish feed industry, including all supply chain processes, is crucial for farm profits. Fish farmers in Bangladesh complain about low quality, high prices, poor transport, and delivery services, and unfavorable transaction policies (FAO, 2015) and these complaints hint at severe inefficiencies in the feed supply chain. To the best of our knowledge, this has not gained interest from field researchers.

It is expected that supply chain actors have a benchmark for assessment that results from internal longitudinal or external cross-sectional comparisons on products, processes, and services (Estampe *et al*., 2013). A perceived benchmark and business reality develop an actor's expectation of the performance of others. This expected performance can be compared to the perception of one's own current performance, leading to the identification of performance gaps for an attribute, actor, or whole supply chain (Lu *et al.,* 2019). With the focus on perceptions and expectations rather than hard factors only, earlier studies have defined this as an expectation gap (Lu, Ertek & Betts, 2014; Lu & Ertek, 2015). In this paper, we adopt an understanding of inefficiencies as the driving force behind the gap between expected performance and perceived current performance.

The aim of this paper is to shed light on the performance of the fish feed supply chain in Bangladesh by measuring the difference between expected performance and perceived current performance – the performance gaps at the level of individual stages in the supply chain and in the supply chain as a whole.

Supply chain performance can be measured using different metrics, depending on the perspective and the nature of businesses (Gopal &Thakkar, 2012). Financial performance is the main issue, but it is insufficient to measure a supply chain without calculating operational performance (Flynn *et al.*, 2010). The supply chain operation reference (SCOR) model have emerged as the foundation of supply chain performance assessment systems and Akyuz and Erkan (2010) proposed a complete package of levels, attributes, and metrics for measuring supply chain performance.

To determine the supply chain performance, all costs need to be included (Gunasekaran *et al.*, 2001). The total costs consist of logistics, input, production, marketing, and transactions and in an efficient feed supply chain all will be low (FAO, 2015). A key problem in this respect is the measurement of transaction costs (including search, monitoring, and termination costs) (Williamson, 1985), which cannot all be expressed numerically. Direct transaction costs emerge as a direct cost in a calculation (Rindfleisch & Heide, 1997). However, some physical, psychological, and social costs are difficult and sometimes impossible to calculate (Grover & Malhotra, 2003). Because transaction costs might change the cost structure, an assessment of the supply chain performance without considering transaction costs might not lead to adequate interventions. Thus, this paper also explores how transaction cost theory can be applied to detect supply chain inefficiencies. In addition to common performance measurements, this study identifies node-to-node transaction costs in the supply chain to suggest appropriate interventions for the feed supply chain in Bangladesh.

The remainder of this paper is organized as follows. A literature review of supply chain performance measurement as well as the theoretical framework is provided in section 2. A brief description of the fish feed supply chain is provided in section 3. The methodology and data collection are described in sections 4 and 5, respectively, while the results and discussion are presented in sections 6 and 7. Section 8 concludes the paper.

2. PERFORMANCE CRITERIA IN SUPPLY CHAINS: THEORETICAL FRAMEWORK AND LITERATURE REVIEW

A supply chain covers the upstream and downstream flows of products, services, finance, and information from raw materials to consumers (Mentzer *et al.*, 2001). The supply chain consists of different operational phases: plan, source, make, delivery, and return. These phases may be performed by one or many firms and the process can be assessed with various criteria. This is the process-based approach. Assessments of key management hierarchy (strategic, tactical, and operational) of each process present the scenario of that particular stage and reflect the condition of whole supply chain. Both the process and hierarchy-based approach are used to analyze supply chain performance (Balfaqih *et al.*, 2016).

A supply chain can be assessed with different criteria and selecting the right metrics for measuring supply chain performance is difficult (Gopal & Thakkar, 2012). The variation in selection and application of performance attributes, criteria, and metrics depends on the requirement and usability of the subject context. The commonly used performance attributes are cost-saving, quality, reliability, flexibility, delivery time, and deliverability (Gopal & Thakkar, 2012; Gunasekaran & Kobu, 2007; Balfaqih *et al.*, 2016; Akyuz & Erkan, 2010). The attributes are broadly distinguished as financial and non-financial by some researchers. With cost-saving, quality, flexibility, delivery time, and deliverability identified as core criteria (Gunasekaran *et al.*, 2012). However, not all the attributes are of equal importance, and they need to be weighted accordingly using a decision-making tool (Shepherd & Gunter, 2006). Beamon (1999) shows a disproportionate weighting of metrics with cost (42%) taking precedence over non-cost measures such as quality (28%), time (19%), flexibility (10%), and innovativeness (1%).

Many models have been used to assess supply chain performance. In overviews of performance measurement in food supply chains, Zee and Vorst (2005) highlight the need for a process-based approach and emphasize the need for a broad set of performance metrics, which is proposed by Kaplan and Norton (1996) with their concept of the 'Balanced Scorecard'. Lie and Rich (2016) provide a System Dynamics (SD) approach to performance measurement using the framework of value chain analysis. Estampe *et al.*, (2013) analyzed 16 supply chain performance measurement models to show how they applied in different contexts. Among these models, the SCOR model combines all process, hierarchy, and criteria to measure supply chain performance and has been widely used (Sellitto *et al.*, 2015).

The SCOR model was developed by the Supply Chain Council (SCC) in 1996, particularly for analyzing and benchmarking supply chain performance (Gopal &Thakkar, 2012). The model provides a framework of six basic supply chain processes (plan, source, make, deliver, return, and enable) and associated performance criteria (reliability, responsiveness, agility, cost, and asset management) (SCC, 2012). The framework allows for a standardized performance measurement across companies and supply chains which can help identify wasteful practices in the supply chain (Ntabe *et al.*, 2015). The SCOR model comprises four assessment levels, shown in **Table 1**, that define the particular area and context for assessing the supply chain (SCC, 2012).

Identifying the priorities of the criteria is the key issue in managing a supply chain successfully (Gunasekaran & Kobu, 2007). Shepherd and Gunter (2006) point at a limitation of the SCOR model, in that it does not offer a systematic priority of the performance measures. As stated above, this can be overcome by adopting a decision-making tool such as the analytical hierarchy process (AHP).

The analytical hierarchy process (AHP) was introduced by Thomas Saaty (1980). The process makes a pair-wise comparison to set priorities and make the best decision considering subjective and objective aspects. In addition, the process reduces bias by checking the consistency of a decision-makers evaluation. The AHP enables one to break down a complex problem into a hierarchy system (Triantaphyllou, 2000) by calculating the vector of each attribute. The AHP is the best tool for prioritizing and choosing measures and metrics (Gopal & Thakkar, 2012), and it can give a standard and acceptable structure for assessing a supply chain (Palma-Mendoza, 2014).

Table 1 The Hierarchy Level of the SCOR Model

Level	Description	Content (examples)
Level 1	The types and number of processes are determined considering the scope and content of the supply chain.	Plan, source, make, deliver, return, and enable
Level 2	Operational strategy and function capabilities are developed configuring different process categories.	Make to stock, make to order, make to deliver, deliver to payment
Level 3	Decide on individual processes	Receive product, verify product, transfer product
Level 4	Implement the activities within the supply chain	Specific steps of the process

Source: SCOR Process Model (SCC, 2021)

We are not aware of any study applying the SCOR model and the AHP to measure the supply chain performance of the fish feed industry in Bangladesh or any fish value chain. Thus, with this approach, we want to advance research in this field and encourage the diffusion of standard supply chain management tools into studies on feed supply chains.

In addition, because transaction costs have been frequently studied in agricultural supply chains but are not currently an integral part of measuring supply chain performance, we suggest using transaction costs to extend the scope of supply chain performance measurement.

A transaction cost occurs when a good or service is transferred across a technologically separable interface (Williamson, 1981). The cost arises from processes of searching information, communication, negotiation, execution, adaptation, coordination, and controlling between contractual and exchange parties (Dietl, 1993). The theory is based on the assumptions of environmental uncertainty and bounded rationality, assuming that decision-makers suffer from a lack of information, as suggested by Simon (1957). It further assumes that individuals opportunistically seek their self-interest, using immoral or even illegal methods that cannot easily be detected (Williamson, 1985). There are two types of transaction costs: 'ex-ante' costs, which occur before a contract is signed or orally agreed, and 'ex-post' costs, which occur after the contract has been signed (Dyer &Chu, 2003; Williamson, 1996). The costs of searching, finding information, negotiating, developing contracts and agreements are ex-ante costs. The costs related to monitoring, coordinating, enforcing contracts and agreements are ex-post costs (Douma & Schreuder, 2002).

The reduction of conflict and uncertainty reduces transaction costs and increases supply chain performance (Yang, 2014). In that sense, long-term and trustful relationships also reduce transaction costs, improving the performance of the supply chain (Grover & Malhotra, 2003). Given the comparative-static nature of the theory (Williamson, 1991), most studies of transaction costs in supply chains focus on the choice of governance structures among supply chain partners (Hobbs, 1996). Um and Kim (2019) identified that reducing transaction costs can improve buyer performance, and Singh and Teng (2016) state that relational governance improves supply chain performance and reduces transaction costs; however, there has been limited research on transaction costs in determining the performance of a supply chain (Grover & Malhotra, 2003).

3. STRUCTURE OF AND TRANSACTIONS IN THE FISH FEED SUPPLY CHAIN IN BANGLADESH

The fish feed supply chain in Bangladesh consists of domestic and international input suppliers, feed manufacturers, and feed distributors who deliver feed to farmers, as shown in **Figure 1**. In Bangladesh, fish feed ingredients comprise rice bran (20–50% inclusion), maize (5–20% inclusion), soybean meal (10–30% inclusion), mustard oil cake (10–25% inclusion), fish meal (5–15% inclusion) and meat and bone meal (10–20% inclusion); around 45–50 % of fish feed ingredients are imported but 100% of meat and bone meal are imported, mainly from the European Union (Mamun-Ur-Rashid *et al.,* 2013).

Usually, large manufacturers import goods directly but sometimes they buy from importers too. The other ingredients are purchased from local suppliers. Commercial firms produce 1 million tons of formulated feed annually amounting to 71% in total (Mamun-Ur-Rashid *et al*., 2013). Of the commercial firms, 10% are large-scale producers (feed production capacity is 60–90 thousand tons per year),60% are medium-scale manufacturers (40–60 thousand tons per year), and 30% are small-scale producers (10–40 thousand tons per year) (Ahmed,2015). The manufacturers distribute 96–98% of feed to farmers through dealers (Mamun-Ur-Rashid *et al*., 2013). The large firms appoint 450–500 dealers and the medium-sized firms deploy 200–300 dealers countrywide (Belton *et al*., 2011). The manufacturing companies make a contract with a dealer and allow sole distributorship for a particular area. As part of the arrangement, the dealer is locked in, not allowed to sell another company's product in the contracted area. Dealers are responsible for selling to farmers and retailers and occasionally generating favorable publicity for the company.

A study by the UN Food and Agricultural Organization [FAO] (2015) noted some malpractice prevailing in the feed supply chain. This included feed manufacturers – mainly small-scale manufacturers– using cheap protein which resulted in sub-optimal growth of fish. It also noted dealers being accused of improper storage and handling which reduces feed quality, as well as reports of late or no delivery. The situation is worse for the capital constraints of farmers of small and medium-sized farms who depend on trade credit contracts with feed dealers. The terms and conditions of the trade credit contracts allow feed sellers to dominate farmers (Islam *et al.*, 2020b) and it is hard for farmers to switch to different feed sellers. The farmers are contractually obliged to use those dealers and have few means by which to sanction deliveries of low-quality feed (Islam *et al.,* 2020a; Islam *et al.,* 2020b). However, FAO did not specifically focus on individual actors' contributions to supply chain inefficiency, which is the focus of this study.

4. METHODOLOGY

4.1 Applying the Supply Chain Operation Reference (SCOR) Model to the Feed Industry

The SCOR model has been conceptualized to be applicable in any sector or industry. Level 1 of the SCOR model contains the number of stages of a supply chain (SCC, 2012). We took three major phases (source, make, and deliver) of the fish feed supply chain to analyze its performance. *Source* includes local and foreign suppliers of raw materials, *make* refers to feed manufacturing companies, and *deliver* is the dealers appointed by the manufacturers to sell feed to farmers. All the processes work under plan (Sellitto *et al*., 2015). Individual firm works in every phase with separate plan in the supply chain. The plan belongs to each hierarchy than distinct operational process that discourages to take the plan as a separate phase. The three stages related to three distinct actors in the supply chain, whereas *return*, like *plan*, is a common function for all actors. Moreover, *return* is not applicable for all the nodes in the chain, especially for foreign suppliers of raw materials with high shipping charges.

From the attributes and respective metrics proposed in the SCOR model, we selected the first four performance attributes: reliability, agility, cost, and time. We considered these four attributes to be enough to assess the supply chain because they are more influential in transaction decisions; the remaining attribute, asset management, refers to internal issues of each actor. *Cost* includes raw materials, production, and marketing. Cost reduction refers the operational efficiency of actor. *Reliability* includes order fulfillment, share of defective products, and client satisfaction. Companies prefer to deal with responsible suppliers and put pressure on current supplier to do the same (Pattnaik and Pattnaik, 2019). *Agility* refers to flexibility in making and delivering the optimum product and being able to adapt to changes in the market. *Speed* is the time of responsiveness of actors in production and delivery. The attributes and several performance metrics with the value chain are shown in **Figure 1**. The questionnaire used for assessing the performance is provided in Appendix A1.

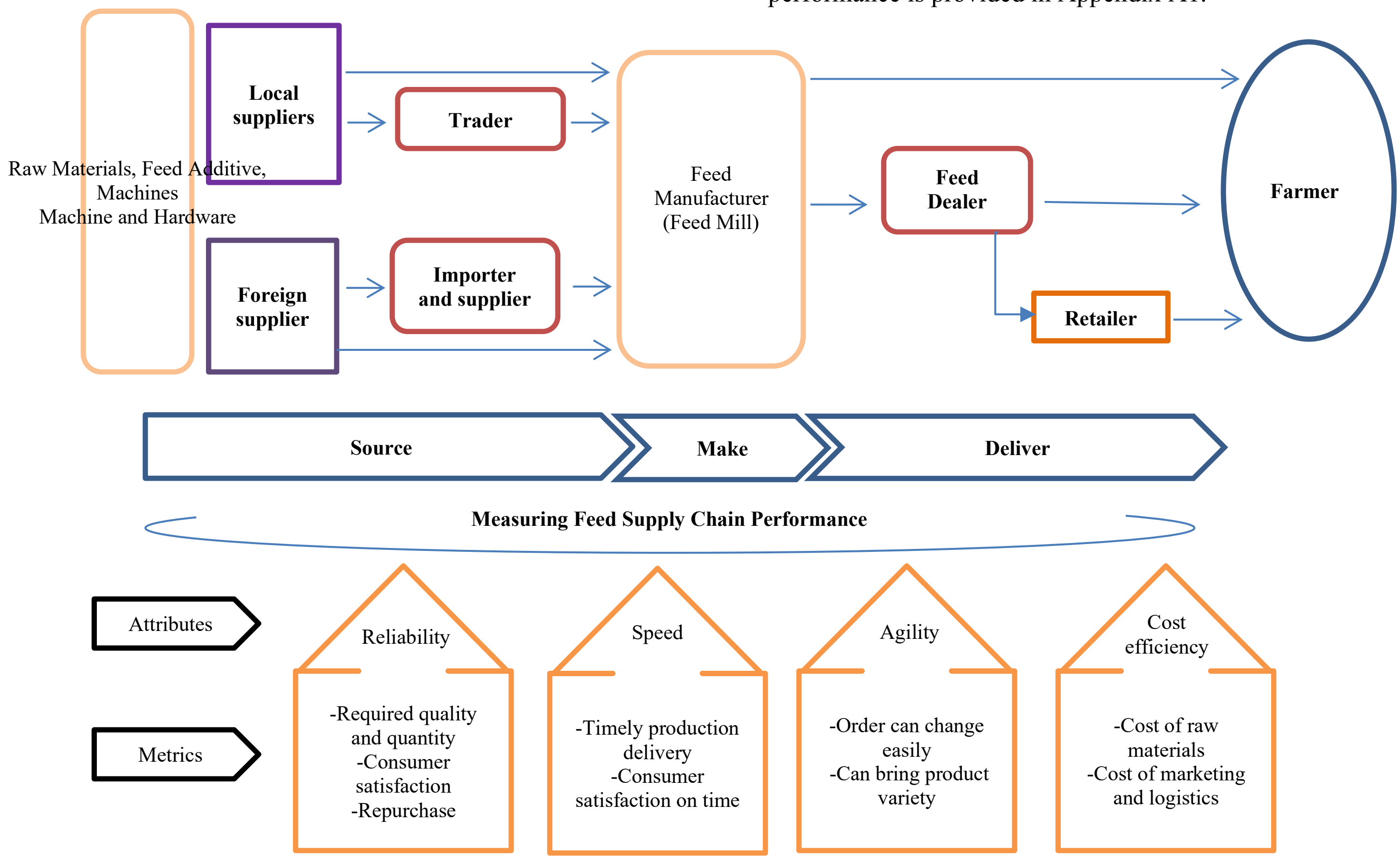

Figure 1 Maps with the Analytical Framework of the Fish Feed Supply Chain in Bangladesh
Source: Authors' own representation based on the work of SCC (2012) and Mamun-Ur-Rashid *et al.*, (2013)

4.2 Identify Relative Weight Using the Analytical Hierarchy Process (AHP)

Having identified the relevant attributes and metrics as the first step of the AHP (Shahin & Mahbod, 2007), we were left with the question of the relative importance of each. Here, we use the AHP to identify, first, the relative weight of each stage in the supply chain and, second, the relative weight of each performance attribute.

For this, we developed an interview schedule for comparisons within the steps and attributes. The study used the 9-point scale of Saaty (1990) for the comparisons: where

1 = i and j carry same weight in importance, 3 = i is slightly more important than j, 5 = i is more important than j, 7 = i is strongly more important than j, 9 = i is absolutely more important than j.

The comparative data were collected through in-depth interviews and focus group discussions and presented in the AHP- based matrix, like A given in (1):

$$A = [a_{ij}] = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \tag{1}$$

A is the matrix containing the comparative weights of two items, $[a_{ij}]$, where a_{ij} is the relative importance of $a_i$over a_j. The matrix A is multiplied by itself to generate the weight vector w_i, describing the importance of A_i relative to all other alternatives. In the matrix A, each weight vector is w_i> 0 and $\sum_{i=1}^{n} w_i$=1.The reciprocity in the matrix is defined: if $i = j$, then a_{ij}=1; if $i \neq j$, then a_{ij}=1/a_{ji}.The decision-maker may face inconsistency in a pair-wise comparison. To check the problem, the consistency index (CI) and the consistency ratio (CR) are calculated, where CR<0.10 is of satisfactory consistency (Najmi and Makui, 2012). In the study, we judge the consistency of data by the consistency ratio.

4.3 Assessing Expected and Current Perceived Performance

To assess the performance of the fish feed supply chain we used qualitative as opposed to quantitative data. The collection of actual financial and operational data were not possible, since the actors were not willing to share their information for the sake of violation of confidentiality. The qualitative elements are also largely ignored in the most of supply chain literature and without that, the real scenario cannot be exposed (Tundys, 2018). Norrman and Naslund (2019) identified the gap between perceived importance of incentives and real practices in the supply chain operation, founded on qualitative data of respondents' various points of view. Sellitto *et al*. (2015) used the qualitative approach to measure the Brazilian footwear supply chain performance based the points of view of the actors. That perceptual aspect of actors also provided the foundation of our study where data were derived using a similar analytical approach.

In the study, both the expected and current perceived performance derived only from actors' perceptions not from any real data of finances, quantities, or speed. The relative weight of a stage or attribute reflects the expectation of the respondent. The study considered the total expected performance of the supply chain is 100, as presented in the expected performance matrix **(Table 3)**. The columns of the matrix comprised the weights of the different supply chain phases and the rows comprised the performance attributes; the multiplication of the column and the row resulted in the elements of the matrix (Sellitto *et al*., 2015).

In the study, we used a structured interview schedule to measure the current perceived performance or observed performance (Appendix A1). The current perceived performance is the observation that is measured by a 100-point rating scale, where 1 represents an extremely poor performance and 100 represents an extremely good performance. The performance ratings are calculated as a percentage of the expected performance in each phase. These percentages then become the observed performance. The difference between the expected performance and the observed performance is the expectation gap or performance gap. The difference between the expected performance and the current perceived performance is the expectation gap or performance gap.

4.4 Calculating Transaction Costs

As mentioned in referring to researchers such as Hobbs (1996) and Grover and Malhotra (2003), the complex nature of firms and market structures makes it hard to collect reliable transaction cost data. In our study, because many inseparable transaction costs (subscription in transport etc.) are included and some actors did not reveal certain costs for reasons of confidentiality, it was close to impossible to calculate precisely the full actual transaction costs. Calculating real transaction costs in a supply chain is close to impossible because of the many inseparable costs. Thus, the perceived transaction costs were measured in the study. We took manufacturers' perception of transaction costs, which considered the supply chain nodes of ingredient suppliers and dealers, and we also took the dealers' perception of the manufacturers. A structured interview schedule (Appendix A2) with the five-point Likert scale (1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High) was used to measure the perceived transaction costs. The mean and standard deviation of the transaction costs represent the costs that occur in the node-to-node transaction. Finally, we developed a comparative table with the result of the transaction costs and performance gap of each actor to identify the low-performing actors and overall inefficiency in the supply chain.

5. SAMPLING AND DATA COLLECTION

We engaged four major actors in the study, ranging from the raw material to the final delivery to farmers. Two types of suppliers (local and foreign), manufacturers of the fish feed, and the dealers who distribute the finished products to farmers are considered to be involved in the feed supply chain. The feed manufacturers were the entry point of this analysis. Although more than 100 companies produce fish feed, only the40 leading producers are the main players in the fish feed market (Belton *et al*.,2011). However, 60–70% of the feed market share is controlled by only 10 large and medium-sized firms (Mamun-Ur-Rashid *et al*., 2013). The feed producers are organized commercial firms, make large investments, have expertise on cost and quality, and maintain very close ties to ingredient suppliers and dealers. Most firms conduct periodic research on feed market demand, changes in market trends, the satisfaction of farmers, and their market share. Firms conduct marketing and promotional activities for farmers. They are supposed to have more in-depth knowledge about the overall industry than other actors. We collected data from 25 feed manufacturers and 105 feed dealers.

Our research comprised face-to-face interviews with dealers and four focus group discussions (FGDs) with representatives of feed manufacturers. We collected data collection from September to November 2017. The feed manufacturers are concentrated in Mymensingh and Gazipur districts in Bangladesh; for logistical ease, the four FGDs took place in the Mymensingh sub-districts of Valuka and Trishal.

The manufacturers' samples were collected from two main strata as stratified sampling, Mymensingh and Gazipur districts having a list from each District Fishery Officer. From each list, 30 companies were selected at random. The District Fishery Officer contacted the selected companies over the telephone. Of the30 selected, 17 feed producing companies agreed to participate; five firms sent more than one representative and 13firms refused to participate due to availability or worries about confidentiality. Finally, 25 participants joined in four FGDs, each FGD comprising five to eight participants. Of the top ten producers, three firms participated. Among the participants, 17% belonged to large, 52% medium-sized and 31% were from small companies. The participants were from mid to top managerial positions; further characteristics of the sample participants are shown in **Table 2**.

Table 2 The Characteristics of Sample

	Feed manufacturers (n=25)		Feed dealers (n=105)	
Characteristics	Mean	Standard deviation	Mean	Standard deviation
Age	45	12	48	7
Education (years)	16	2	12	2
Experience (years)	13	7	10	6
Data collection method	Focus group discussion and in-depth interview		Standardized face-to-face interview	
Location	Mymensingh, Gazipur		Mymensingh, Comilla, Bogra, Khulna, Jessore, Bhola and Chittagong	

Two researchers worked as facilitators in each FGD. Each one was conducted on separate days and took about two hours to complete. Data were recorded using audio recordings and handwritten notes.

At the beginning of the FGDs, the objectives of the study were outlined and, as discussion icebreakers, we discussed business practices and the current situation of the fish feed industry. Following the before mentioned mixed methods approach (Burgess, Limb &Harrison, 1988), the discussion followed a pre-specified guideline on priorities of supply chain processes and attributes. After the discussions, the interviews were used to collect data on transaction costs and to score the current performance of the supply chain (Appendices A and B).

The dealers were randomly selected from prominent feed markets in seven major pangasius and tilapia production regions, which contribute 72% of total aquaculture production in Bangladesh (DOF, 2016). Local fishery officers provided the market list. The interviews (Appendices A, B) were used to generate data from dealers.

6. RESULT

From the FGDs, we found that commercially formulated feed accounts for 78% of total fish feed production; the remaining 22% are non-brand firm-made feed. Only 16 companies account for 75% of commercial feed market share. Feed production was a very profitable business 10 years ago, but now margins are squeezed for higher costs and greater market competition. More than 100 feed producers operate nationally, but, in contrast, only up to approximately 20 dealers operate in any single location. Sales and distribution is the most challenging aspect for a company because of the lack of good dealers. Approximately 20% of dealers violate contract terms by selling the products of multiple brands. Markets for both domestic and international raw material are competitive and that makes it easier to find suppliers for ingredients. However, ingredient prices in the global market have been rising rapidly in last few years, which is a challenge for ensuring better quality feed at the current price.

The expected performance of the supply chain, as shown in **Table 3**, was developed by combining the outcome of two AHP-based matrices: the priority of process and the performance attributes. The consistency ratio (CR) for the supply chain process was calculated as 1.6% and the CR for the weight of performance criteria was calculated as 8.3%. Both the results were acceptable because values of that CR that are less than 10% are assumed to not affect the final outcome of the analysis (Barzilai, 1998).

Table 3 Weighted Expected Performance of the Feed Supply Chain

		Reliability (%)	Cost (%)	Agility (%)	Speed (%)	Total (%)	CR (%)
		57	27	11	5	100	8.3
Source	29%	16.53	7.83	3.19	1.45		
Make	22%	12.54	5.94	2.42	1.1		
Deliver	49%	27.93	13.23	5.39	2.45		

Note: source = ingredient supplier, make = manufacturing firm, deliver = feed dealer

Table 3 Weighted Expected Performance of the Feed Supply Chain (con't)

		Reliability (%)	Cost (%)	Agility (%)	Speed (%)	Total (%)	CR (%)
Total	100%						
CR	1.6%						

Note: source = ingredient supplier, make = manufacturing firm, deliver = feed dealer

In the expected performance matrix in **Table 3**, deliver records the highest weight of expected performance in the supply chain (49%). This is the expected performance from the dealer, which is then divided into its constituent parts of reliability (27.93%), cost (13.23%), agility (5.39%), and speed (2.45%). Among the performance attributes, reliability takes the highest weight (57%) in the supply chain. Cost is always important, but it takes the second position behind reliability. The dealer was the most important actor in the supply chain, followed by raw material suppliers and manufacturers. The expected performance of the whole supply chain is 100 (Source 29, make 22, deliver 49). For the two suppliers that appeared in the supply chain, the expected performance was 14.5 each, making 29 in total for the ingredient supplier. The expected and current perceived performance of every actor with all attributes of whole supply chain is shown in **Table 4**.

Table 4 The Performance of Fish Feed Supply Chain

Actor (weight)	Performance attributes	Weighted expected performance (%)	Average marks on performance (out of 100)	Weighted current perceived performance (%)
Source (Input Supplier)				
*Local (*14.5%*)*	Reliability	8.27	87.67	7.25
	Speed	0.73	88.50	0.64
	Agility	1.60	91.50	1.46
	Cost	3.92	54.00	2.11
*Foreign (*14.5%*)*	Reliability	8.27	91.33	7.55
	Speed	0.73	92.00	0.67
	Agility	1.60	90.00	1.44
	Cost	3.92	53.00	2.07
	Sub total	**29.00**		**23.19**
Make (Feed Manufacturer: 22%)	Reliability	12.54	82.00	10.28
	Speed	1.10	93.00	1.02
	Agility	2.42	81.50	1.97
	Cost	5.94	53.00	3.15
	Sub total	**22**		**16.43**
Deliver (Feed Dealer: 49%)	Reliability	27.93	77.50	21.65
	Speed	2.45	71.00	1.74
	Agility	5.39	64.50	3.48
	Cost	13.23	43.50	5.76
	Sub total	**49**		**32.62**
	Total	**100.00**		**72.23**

Note: The detailed calculation is at Appendix A

As **Table 4** shows, for the whole supply chain, the expected performance on reliability of the dealer was 27.93. The respondents marked 77.50 out of 100 on current performance. The current perceived performance was calculated as 27.93 x 77.50% = 21.65. The observed performance of the whole supply chain was 72.23. The chain scored approximately 85% on two attributes, speed, and agility. The score for the cost is 50%, which is lower than other attributes. Moreover, we assessed node-to-node perceived transaction costs in the supply chain separately, as presented in **Table 5**. The summary statistics present the extent of the transaction costs as perceived by respondents.

The ex-post costs are comparatively higher than the ex-ante costs. The mean and median for each actor are very close, suggesting consistency of opinion. The average perceived cost is low for both suppliers but medium to high for dealers. The performance gap is an indicator of inefficiency of both the individual actors and the whole supply chain. To evaluate the supply chain, two indicators, performance gap and transaction costs, are presented in **Table 6**.

The performance achievement for dealers (67%) is slightly lower than that of the other actors, whose results are more closely matched. The total performance gap of the supply chain is 27.77%, with dealers contributing 16.38%. Both the transaction costs and the performance gap are high for dealers. The low transaction costs and low performance gaps for both local and foreign suppliers show a linear relationship.

7. DISCUSSION

Both performance criteria and transaction costs detected a performance gap that reflects inefficiency and an area for intervention in the chain. The results show that the transaction costs and performance have an inverse relationship: high transaction costs indicate low performance and vice versa. Transaction costs are an indicator of efficiency for both individual actors and the whole supply chain (Grover & Malhotra, 2003). Thus, we can say that transaction costs indicate the performance of an actor in the supply chain.

Table 5 The Perceived Transaction Costs in the Fish Feed Supply Chain

Transaction Cost	Local Supplier			Foreign Supplier			Feed Manufacturer			Feed Dealer		
	Mean	St. dev.	Med..	Mean	St. dev.	Med.	Mean	St. dev.	Med.	Mean	St. dev.	Med.
Ex-ante costs												
Getting information on a transaction partner	1.33	0.58	1	1.67	0.58	2	1.45	1.3	1	1.33	0.58	1
Finding a proper business partner	2.33	0.58	2	1.67	0.58	2	3.56	1	3	4.33	1.15	5
Reaching an agreement	2	1	2	1.67	1.15	1	3	2	2	4.33	0.58	4
Signing the contract	1.67	0.58	2	1.67	0.58	2	2	0.58	2	2.67	2.08	2
Ex-post costs												
Monitoring	2	1	2	2	1	2	3.5	2	3	4.33	0.58	4
Breach of contract	2	1	2	1.67	1.15	1	2.5	1.5	2	4.33	0.58	4
Co-ordination	2.67	1.53	3	2.67	1.53	3	2	1.67	1	3.67	0.58	4
Average transaction costs	**2**	**0.89**	**2**	**1.86**	**0.94**	**1.86**	**2.57**	**1.44**	**2.00**	**3.57**	**0.87**	**3.43**
	Low			**Low**			**Low to medium**			**Medium to High**		

Source: Author's survey conducted in 2017
Note: The mean and median are based on a 1–5 Likert scale, (1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High); St. dev. = Standard deviation; Med. = median

.About 28% performance gap indicates a level of inefficiency in the feed supply chain. Reliability is the main issue of concern, but cost is the main reason for low performance. The lower score for cost across the whole chain indicates it is something with which all actors are dissatisfied. The increase in prices of import-dependent ingredients and the costs of logistics are responsible for the increase in the total cost, resulting in challenges for the chain. Considering the price-sensitive feed market, some manufacturers have had to make trade-offs between price and quality to retain their customer base. Because the high price is unaffordable for the farmers, they tend to buy cheaper and low-quality feed which results in outputs of low yields. The quality compromise is high with small-scale feed producers (FAO, 2015) and the conflict between price and quality is being faced by the whole chain. However, the study shows the overall transaction cost is not high. Market demand is changing, for example the shift in demand from sinking feed to floating feed, and, consequently, actors' adaptability and flexibility are important too.

Table 6 Comparative Performance of the Supply Chain (Represented in Percentages)

Actor	Expected performance	Current perceived performance	Performance gap	Performance achievement	Perceived transaction costs
Local supplier	14.50	11.46	3.04	79	Low
Foreign supplier	14.50	11.73	2.77	80	Low
Feed Manufacturer	22.00	16.43	5.57	75	Low to medium
Feed Dealer	49.00	32.62	16.38	67	Medium to high
Total	100.00	72.23	27.77	72	

In comparison of actors, performance gaps exist across the board, but dealers are the lowest performing. The low achievement and high transaction costs of dealers indicate the problematic area of the supply chain. Because of the weight that dealers carry in the supply chain, the effect of their low performance is greater than that of other actors. In a given location, there are typically few dealers and plenty of manufacturers. Thus, the switching costs for dealers are expected to be low because they can find another company easily. For their professional behavior, the foreign suppliers are more reliable than local suppliers.

The results suggest that feed manufacturers consider alternative distribution channels more than dealers. A company can establish a direct sales channel to farmers via information technology or its own retail stores. Manufacturers can do it jointly; the horizontal co-ordination among the feed manufacturers in the value chain can reduce the transaction costs of dealing with other actors (Neven, 2014). Developing local sources can relieve the industry of its dependence on expensive imported ingredients. The quality compromise of small manufacturers can be reduced by effective implementation of the Fish Feed and Animal Feed Act, 2010 and Fish Feed Rules, 2011. Still the feed sector remains largely unregulated (FAO, 2015) due to poor implementation of law (Alam & Ahammad, 2017).

8. CONCLUSION

In our analysis, we found that inefficiency prevails in the fish feed supply chain in Bangladesh. The whole chain struggles with high costs and this leads to compromises in quality. Foreign suppliers were the best performers for their structured business and professionalism, followed by local suppliers, manufacturers, and dealers. In assessments of both transaction costs and performance gaps, dealers were the most inefficient actor. Feed producing companies can develop alternative distribution channels to dealers.

The total cost was high in all the phases but transaction costs were comparatively low; a result that justifies separately calculating transaction costs to get an accurate view of the supply chain. Transaction costs show a positive relationship with the supply chain performance gap. However, transaction costs are inevitable and can be used as a metric for measuring the performance of a supply chain. Using both transaction costs and performance metrics to detect the performance gap in a chain is a new dimension to supply chain analysis. This new dimension would be widely applicable to measuring performances of supply chains in many sectors.

The study's first limitation was that the data was not collected from raw material suppliers and farmers and consumers' perception was not reflected. The second limitation was that the research did not consider the farm-made non-brand feed. The study represented an approximation of the whole fish feed industry rather than the entire industry.

The research could be further refined by using larger surveys, bigger data sets, and interviews with every actor in the supply chain. Using inferential statistics to understand the cause-and-effect relationship of transaction costs, supply chain performances, and intervention policy may be a new area of research to pursue.

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APPENDIX A: SCHEDULE FOR THE INTERVIEWS ABOUT THE SUPPLY CHAIN PERFORMANCE AND TRANSACTION COSTS

1. Interview Schedule and the Detailed Findings of the Feed Supply Chain Performance

Actor	Performance attributes	Performance indicator	Optimum performance (%)	Measured performance (out of 100)	Value added (%)
Supply					
Local 14.5%	Reliability	The supplier used to provide the raw materials as per requirement	2.76	85	2.34
	Reliability	The supplier used to fulfill the order perfectly.	2.76	88	2.42
	Reliability	The supplier provides zero defect products.	2.76	90	2.48
	Time	The raw materials delivery is just in time.	0.36	91	0.33
	Time	From order to delivery, total cycle time of supplier is satisfactory to you	0.36	86	0.31
	Agility	The order can make or change easily.	0.80	88	0.70
	Agility	You have got many alternative suppliers.	0.80	95	0.76
	Cost	The raw materials price is reasonable.	3.92	54	2.11
		Total local supplier	14.50		11.46
Foreign 14.5%	Reliability	The supplier used to provide the raw materials as per requirement	2.76	90	2.48
	Reliability	The supplier used to fulfill the order perfectly.	2.76	93	2.56
	Reliability	The supplier provides zero defect products.	2.76	91	2.51
	Time	The raw materials delivery is just in time.	0.36	95	0.34
	Time	From order to delivery, total cycle time of supplier is satisfactory to you	0.36	89	0.32
	Agility	The order can make or change easily.	0.80	85	0.68
	Agility	You have got many alternative suppliers.	0.80	95	0.76
	Cost	The raw materials price is reasonable.	3.92	53	2.07
		Total Foreign supplier	14.50		11.73
		Sub total	***29.00***		***23.19***
Manufacturing	Reliability	Make as per customer requirement	6.27	94	5.89
22%	Reliability	You can make zero defect products.	6.27	70	4.39
	Time	The production maintains just in time.	0.55	97	0.53
	Time	From raw to finish product, total production cycle time is satisfactory to you.	0.55	89	0.49
	Agility	You can produce required quantity easily, whatever it is.	1.21	90	1.09
	Agility	You can produce various quality products easily.	1.21	73	0.88
	Cost	The production cost is optimum	5.94	53	3.15
		Sub total	***22.00***		***16.43***
Distribution	Reliability	How much satisfied your customer is	13.97	75	10.47
49%	Reliability	Repurchase rate of your customer is	13.97	80	11.17
	Time	You deliver the product to customer at just in time.	1.23	72	0.88
	Time	Customer satisfaction on cycle time.	1.23	70	0.86
	Agility	Alternative buyer you have	2.70	48	1.29
	Agility	You are capable to adapt with market change.	2.70	81	2.18
	Cost	The logistic cost is satisfactory. (Level of truth of the statement)	6.62	47	3.11
	Cost	The marketing cost is reasonable. (Level of truth of the statement)	6.62	40	2.65
		Sub total	***49.00***		***32.62***
		Total	**100.00**		**72.23**

2. Interview Schedule of Transaction Cost

Transaction cost	Very Low = 1	Low = 2	Moderate = 3	High = 4	Very High = 5
1.The cost is incurred to get the information of the transaction partner					
2.Cost is needed to find a suitable business partner					
3.The cost required to reach in agreement					
4.The expenditure on contract signing					
5.Cost required for monitoring the counterpart					
6.Cost of legal action, if the counterpart violates the contract					
7.Cost required for maintaining the coordination					

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