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THREE STAGE SUPPLY CHAIN COORDINATION AND PROFIT OPTIMIZATION OF AGRICULTURAL PRODUCTS IN BANGLADESH

Mohammad Khairul Islam[a,*], Md. Mahmud Alam[a], Mohammed Forhad Uddin[b], Gazi Omar Faruque[c]

[a] *Department of Mathematics, Dhaka University of Engineering and Technology*
[b] *Department of Mathematics, Bangladesh University of Engineering and Technology*
[c] *Department of Computer Science & Engineering University of South Asia Banani*

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2 Optimization
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6 Uncertainty

A B S T R A C T

This research presents four different mathematical formulations for the coordination and three stage supply chain optimization of agricultural products in Bangladesh. In this analysis, we assumed that the producers-retailers-distributors are coordinated by mutually sharing their information. To developed a Mixed Integer Linear Programming (MILP) model and analyze the situation of insufficient production capacity for the producer as the reason for shortages. The producers will coverage these shortages by outsourcing, which decided very beginning of the SCN. This plays a very important role in deciding so as to mitigate these challenges and to extend the system performance and individual gain of the SCN. The coordinated mechanism among the members of the market players has been projected to realize the best answer. The SCN was modeled using a formulation in mixed integer linear programming (MILP) that maximizes the total profit and also to estimate the product distribution of different locations which satisfy most of the customer demand. The formulated MILP model were solved by a mathematical programming language (AMPL) and results obtained by appropriate solver MINOS. Numerical example with the sensitivity of several parameters has been deployed to validate the models. Results show that after coordination, the individual profits could be increased without any extra investment.

1- Introduction

The supply chain network (SCN) of a company consists of various functions at every drafting board. The SCN functions will be loosely classified by Ganeshan et al. [1] in the following four classes – location, production, inventory, and transportation. Each function plays important role the entire SCN activities. Pourakbar et al. [2] descried an integrated four-stage SCN, considering single provider, multiple producers, distributors and retailers.Brandenburg et al. [3], define SCN is the coordination of the physical, logical and money flows system among the entire network whole final goal is to deliver the whole system properly. The SCN may be a complicated method presented by Nickel et al. [4],

* Corresponding author, khairulamc@gmail.com

though Papageorgiou [5] proved that associate economical SCN style and resource allocation over the network is crucial for a decent performance of the SCN.

Coordination among the members of supply chain network in business activities is one of the vital issues to overcome the new challenges of the comprehensive enterprise. I n the entire SCN, each party always attempt to enhance his own profits only, so implementation of coordination system is very essential for optimal solution. That is why to ensure the optimal system and satisfy customer demands in today's competitive markets; significant information needs to be shared along the supply chain Network. Ahumada et al. [6], Rong et al. [7] and Aung et al. [8] presents SCN coordination and optimization of production planning, products distribution and profit sharing among them. Vander Vorst et al. and Shukla et al. [9-10] described SCN for the environmental impacts like operational activities, transportation etc.

A large quantity of literature obtainable on SCN analyzed many researchers with various aspects of the topic. Huge number of models considering the combined optimization areas for various business functions location, production, inventory and transportation. Due to high customer expectation, all kind of business effort have been solidified their SCN for feasible business operations. Goyal [11] described a single vendor-buyer inventory models which optimist the total cost. Sajadieh, M.S. et al. [12] optimize shipment, ordering and pricing policies for two stages SCN with price sensitive demand. Drezner et al. [13] described Facility Location Problems (FLP) under the situation of producing plants. Hung et al. [14] presented the situation allocation with reconciliation needs among Distribution Centre (DC). Jose et al. [15] presented MILP model to minimizing time and number of auto for a capacitated vehicle routing drawback and they solved it numerically. Yamada et al. [16] investigated super network equilibrium model. They also investigated the interaction between transport networks and SCN.

In this study, producer-retailer-distributor multi-product, multi-distribution center and multi-customer location production problem is formulated as a MILP model which maximizes the total profit, and at the same time optimizes production land, profitable distribution center. We have incorporated the possibility of external procurement by the producer when it faces shortages and extended the model by considering the interested of the wholesaler also as long term partnership is described by the business entities in today's business environment. The wholesalers purchase the item from the producer and sell it in the market. To solve these formulated MILP model using AMPL with appropriate solver MINOS. Finally, a numerical example along with the sensitivity of relevant parameters is considered to estimate the achievement of the models.

The rest of this study is organized as follows: section 2 discusses data collection. In section 3 presents three mathematical formulation of MILP model which deals with the stage of research methodology. In section 4, discuss the solution procedure and numerical example. Results discussion and sensitivity analysis of our proposed model is described in section 5. Finally, in section 6, presents the conclusions and suggestions for the future work.

DATA COLLECTION

Data collecting may be a crucial step, since the actual information influences the results of the study. If the results accuracy defines the problem under study, those results enable deeper information of the problem. Typically this stage consumes a long time, and contributes to correct information and to supply input to the mathematical model.

We tend to developed our MILP model by collecting actual information for agricultural product optimization in at random elite samples of 235 market players who are directly or indirectly involved in agricultural business from four districts of Bangladesh, additionally the data gathered for this study area unit associated with customers and suppliers; types of products; fixed and variable prices associated to installation of plants, warehouses, distribution centers and agricultural products hub facilities; transportation prices, process and transportation times associated to transportation modes. The mathematical model consists in an exceedingly ancient SC, during which flows area unit initiated from suppliers and finish in customers. Thus, the SCN consists within the following entities: suppliers, productions facilities, DC, WH, agricultural products hubs and markets. Every entity is delineated by its geographical location and therefore the entities area unit connected through the fabric flows between them.

MODEL FORMULATION

This section describes the proposed mathematical formulation. Before mathematical formulation of MILP models, we have discussed indices, sets, parameters and decision variables that are relevant with our work in this study.

Sets:

L: Set of production locations indexed by l;
C: Set of customers indexed by j;
P: Set of products indexed by i

Parameters for producer model:

u_{il} The price of i^{th} product at l^{th} location ($/kg)
l_{il} Labor Requirement of i^{th} product at l^{th} location (ha)
v_{il} Labor cost of i^{th} product at l^{th} location ($/unit)
w_{il} The amount of water need of i^{th} product at l^{th} location (ha)
g_{il} Water cost of i^{th} product at l^{th} location ($/unit)
f_{il} Fertilizer Requirement of i^{th} product at l^{th} location (kg/ha)
c_{il} The price of unit raw materials for i^{th} product at l^{th} location ($/unit)
r_{il} The amounts of raw materials need to produce i^{th} product at l^{th} location ($/unit)
t_{il} Unit transportation cost of raw materials for i^{th} product at l^{th} location ($/unit)
p_{il} The production cost of i^{th} product to l^{th} location at ($/unit).
h_{il} Unit holding cost of i^{th} product from l^{th} location for some given unit of time ($/unit-time)
${g^*}_{il}$ Fertilizer cost of i^{th} product at l^{th} location ($/unit).
p_i Uncertainty probability of i^{th} product
d_{ij} Unit demand of i^{th} product for j^{th} customer

$TCLA$, is the total cultivated land available
TWA, is the total amount of water available

Parameters for wholesaler model:

U^1_{li} Annual fixed cost for l^{th} DC operation of i^{th} product
U^2_l Annual fixed cost for l^{th}DC operation
U^3_{li} Unit producing cost of i^{th} product for l^{th} DC
U^4_{liJ} Unit shipment cost of i^{th} product for j th customer through l^{th} DC
U^5_{li} Unit holding cost of i^{th} product for l^{th} DC
U^6_{liJ} Unit transportation cost of i^{th} product for j th customer through l^{th} DC
D_{IJ} Unit demand of i^{th} product from j thcustomer
Ca_{lI} Products capacity of i^{th} product for l^{th} DC
T_{lj} Unit transportation time from l^{th} DC to j thcustomer

Parameters for retailer model:

f_{li} Retailer fixed cost of i^{th} product at l^{th} location ($/kg)
p_{lij} Retailer production cost of i^{th} product at l^{th} location for j^{th} customer ($/kg)
H_{lij} Retailer holding cost of i^{th} product at l^{th} location for j^{th} customer ($/kg)
pc_{li} Retailer production capacity of i^{th} product at l^{th} location (kg)
tt_{lj} Retailer unit time transportation at l^{th} location for j^{th} customer (h)
rt_{lj} Retailer required delivery time transportation at l^{th} location for j^{th} customer (h)
$rt^*{}_{lj}$ Retailer obligatory time transportation at l^{th} location for j^{th} customer (h)
p_{ij} Retailer penalty cost of i^{th} product for j^{th} customer ($/kg)
Tc_{ij} Retailer unit transportation cost at l^{th} location for j^{th} customer ($/kg)
mc_l Retailer unit maintenance cost at l^{th} location ($/kg)
d_{ij} Unit demand of i^{th} product from j^{th} customer (kg)
pp_{li} Retailer purchasing price of i^{th} product at l^{th} location ($/kg)

Decision variables for producer:

x_{li} Ordered quantity of i^{th} product for location l (unit)
n_i Number of shipment of i^{th} product (unit)
x_{lij}, is the total amount of i^{th} product shipped from l^{th} location/distribution center for j^{th} customer (kg)

$$X_l = \begin{cases} 1, if \;\; location\ l\ is\ used, \\ 0, else \end{cases}$$

$$W_{lj} = \begin{cases} 1, if \;\; customer\ \ j\ is\ used\ distribution\ center\ l, \\ 0, else \end{cases}$$

Producer Model:

Objective function,

$$Maximize, Z = z_1 - z_2$$

Where,

$$z_1 = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n} s_{li} x_{lij}$$

and

$$z_2 = \sum_{l=1}^{L} \alpha_l x_l + \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n} ((t_{li} + c_{li}) r_{li} + (p_{il} + h_{il}) x_{lij} + v_{li} l_{li} + w_{li} g_{il} + f_{li} g^{*}_{li})$$

Subject to constraints,

$$\sum_{l=1}^{L}\sum_{i=1}^{m} x_{lij} \le TCLA$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} L_{li} x_{lij} \le TLA$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} W_{li} x_{lij} \le TWA$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} F_{li} x_{lij} \le TFA$$

$$\sum_{l=1}^{L} x_{lij} \le d_{ij} \quad , \forall i,j$$

$x_{lij}, F_{li}, W_{li}, L_{li}, h_{li}, p_{li}, c_{li}, r_{li}, v_{li}, f_{li}, w_{li}, l_{li}, g_{li}, g^{*}_{li}, t_{li}, ud_{lij}$, *TCLA, TLA, TWA, TFA* are non-negative and x_l is binary.

Distributor Model:

The objective function of the model is difference between total income and total cost:

$$Maximize, z^{*} = z_3 - z_4$$

Where z_3 is the total income and z_4 is the total cost.

$$z_3 = \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} s^{**}_{li}$$

$$z_4 = \sum_{l=1}^{L}\sum_{i=1}^{m} y_l u^{1}_{li} + \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} u^{2}_{lji} + \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} u^{3}_{lji} + \sum_{l=1}^{L} x_l u^{4}_{l} +$$
$$\sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} u^{5}_{lji} / 2 + \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} w_{lj} u^{6}_{lji}$$

Subject to constraints:

$$\sum_{l=1}^{L} x_{lij} \le d_{ij} \quad , \forall i,j$$

$$\sum_{j=1}^{n} x_{lij} \le ca_{li}, \forall i,l$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} \le \alpha\ y_l\ ,\forall l$$

$$\sum_{l=1}^{L} w_{lj} = 1\ ,\forall ,j$$

X_{lji}, $s^{**}{}_{li}$, U_l^1, U_{lji}^2, U_{lji}^3, U_l^4, U_{lji}^5, U_{lji}^6, d_{ij}, Ca_{li}, α are non-negative and y_l, w_{lj} are binary $\forall$ *j,i,l*

Decision variables for retailer:

Z_3, is the total income
Z_4, is the total cost
Z^*, is the maximum profit
$S^*{}_{li}$, is the retailer selling price of i^{th} product at l^{th} location ($/kg)

$$z_l = \begin{cases} 1, if\ \ location\ l\ is\ used, \\ 0, else \end{cases}$$

$$y_{lj} = \begin{cases} 1, if\ \ customer\ \ j\ \ is\ assaign\ to\ \ producer\ l\ , \\ 0, else \end{cases}$$

Retailer Model:

Objective function,

Maximize, $Z^* = Z_3 - Z_4$

Where,

$$Z_3 = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n} s_{li}^{*} x_{lij}$$

$$Z_4 = \sum_{l=1}^{L} x_l\, y_{li} + \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n} (Tc_{ij}\, x_{lij} + (p_{ilj} + h_{ilj} + mc_l)\, x_{lij} + d_{ij}\, p_{ij}(rt_{ij} - rt_{ij}^{*}))$$

Subject to constraints,

$$\sum_{l=1}^{L}\sum_{i=1}^{m} x_{lij} \le \sum_{i=1}^{m} d_{ij}\ ,\forall j$$

$$\sum_{l=1}^{L}\sum_{j}^{n} x_{lij} \le \sum_{j=1}^{n} d_{ij} ,\forall i$$

$$\sum_{l=1}^{L} x_{lij} \le d_{ij}\ \ ,\forall i,j$$

$$\sum_{j=1}^{n} x_{lij} \le ca_{li} ,\forall i,l$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij} \le \alpha\ x_l\ ,\forall l$$

$$\sum_{l=1}^{L} y_{lj} = 1, \forall j$$

$\boldsymbol{x_{lij}, Tc_{ij}, d_{ij}, h_{lij}, p_{lij}, mc_l, d_{ij}, p_{ij}, rt_{ij}, rt^*_{ij}}$ **are non-negative and** $\boldsymbol{x_l}$ **,** $\boldsymbol{y_{li}}$ **are binary** $\boldsymbol{\forall\ l,i,j}$.

Producer-Distributor-Retailer coordinated Model

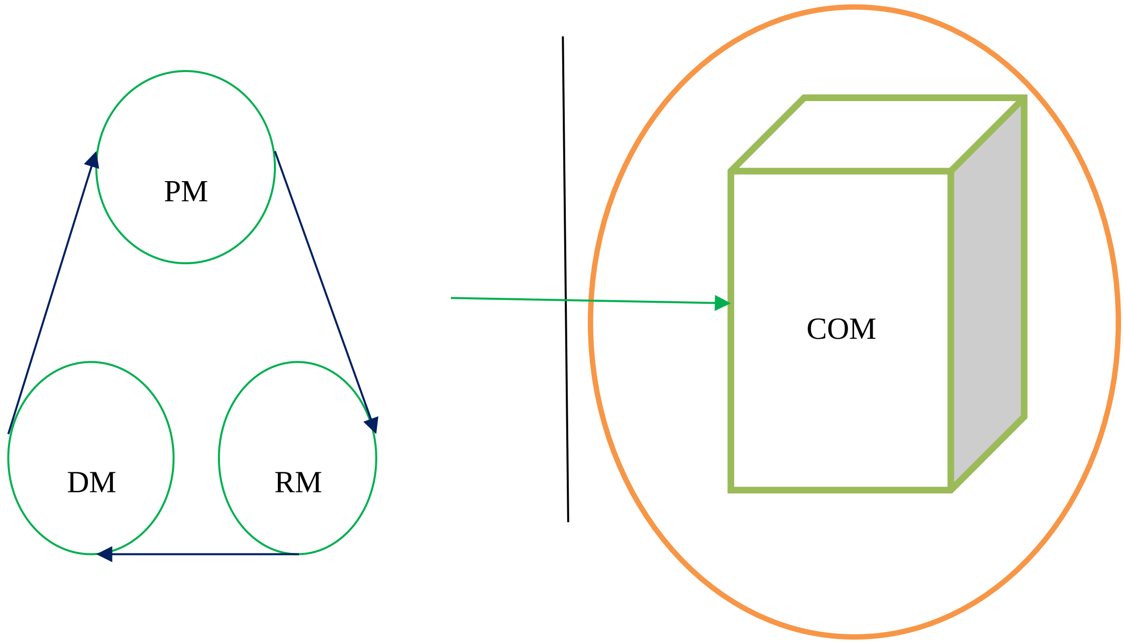

Fig 1. Supply chain coordination model among the participants

In this study, the non-coordinated model convert into a supply chain coordination model where we assume that among the distributor, the retailer and the farmers take decisions jointly and the farmers and retailers decides to go for order shortfall is recover by external sources. If $\beta 1$ (0<=$\beta 1$<=1) is not a whole number of the demand deficiency, which restore by external sources. Hence the new profit equations of the farmer, retailer and the distributor are respectively as follows:

$$z_1 = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[x_{lij} + \beta 1(d_{ij} - x_{lij})]c_{li}$$

$$z_3 = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[x_{lij} + \beta 1(d_{ij} - x_{lij})](s_{li} - c_{li})$$

$$z_5 = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[x_{lij} + \beta 1(d_{ij} - x_{lij})](s^*_{li} - s_{li})$$

Consequently, the coordination return is given by,

$$Z = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[\{x_{lij} + \beta 1(d_{ij} - x_{lij})\}c_{li} + \{x_{lij} + \beta 1(d_{ij} - x_{lij})\}(s_{li} - c_{li}) +$$

$$\{x_{lij} + \beta 1(d_{ij} - x_{lij})\}(s^*_{li} - s_{li})]$$

Which simplified, we have

$$Z = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[(1-\beta 1)x_{lij} + \beta 1 d_{ij}]s^*_{li}$$

Therefore the coordination profit is given by

$$Maximize, Z = \sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}[(1-\beta 1)x_{lij} + \beta 1 d_{ij}]s_{li}^{*} - [\sum_{l=1}^{L}\sum_{j=1}^{n}\{\alpha_l w_{lj} + (c_{li} + t_{li})r_{li}\} +$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m}\sum_{j=1}^{n}(p_{lij} + h_{lij} + mc_l)x_{lij} + \sum_{l=1}^{L}\sum_{i=1}^{m} l_{li}v_{li} + f_{li}g_{li}^{*} + w_{li}^{*}g_{li} +$$

$$\sum_{l=1}^{L}\sum_{i=1}^{m} y_l u_{li}^{1} + \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij}(u_{lij}^{2} + u_{lij}^{3})x_{lij} + \sum_{l=1}^{L} x_l u_l^{4} +$$

$$\sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} x_{lij}\frac{u_{lij}^{5}}{2} + \sum_{l=1}^{L}\sum_{j=1}^{n}\sum_{i=1}^{m} w_{lj}u_{lij}^{6}$$

Remaining set of constraints are described in the above three non-coordinated models.

SOLUTION APPROACH AND NUMERICAL EXAMPLE

By using AMPL (AMPL Student Version 20121021) with appropriate solver MINOS, to find the solution of proposed model. We have developed an AMPL code, which consists of an (a) AMPL model file, containing the actual program, (b) AMPL data file, containing data for the various parameters and (c) AMPL run file. This program has accomplished on a Core-I3 machine with a 3.60 GHz processor and 4.0 GB RAM.

To analyze the effectiveness of the proposed models, we consider a numerical example, which consisting 5 production locations, 5 products and 2 customers (5L-5P-2C). The deterministic demand of unit products of customers are (4600, 3150, 2550, 2870, 3500) and (5600, 2000, 2200, 4650, 2700), producer fixed costs of per unit products (in BDT) for each locations are (14400, 15400, 15300, 14500,15000), (13600, 14600, 14600, 14500, 15400), (13700, 15800, 14800, 14700, 14600), (13800, 15700, 15500, 14600, 14700), and (14500, 14600, 14600, 15500, 15400); retailer fixed of per unit products (in BDT) for each locations are (7000, 5400, 5300, 4500,5000), (3600, 4600, 5600, 5500, 6400), (7700, 6800, 6800, 5700, 5600), (6800, 5700, 7500, 5600, 5700), and (5500, 6600, 7600, 6500, 7400); also distributor fixed costs of per unit products (in BDT) for each locations are (14000, 15000, 14000, 13000,15000), (16000, 16000, 16000, 15000, 14000), (17000, 18000, 18000, 17000, 16000), (18000, 17000, 15000, 16000, 17000), and (15000, 16000, 16000, 15000, 14000) respectively. All types of information don't existent here because of its large volume. The purpose of this example is to provide a consistent logistics support to the wholesaler as well as to find the suitable feasible distribution centers which satisfy most of the customer demands.

RESULT ANALYSIS AND DISCUSSION

In this section, fundamental findings regarding the numerical example of the proposed models as described in Table 1. Which provide the comparative analysis of the decision variables before and after coordination for various shortfall recovering. The percentage of the change of profit for various cases is obtained by the following formula:

$$PI(\%) = \frac{(Total\ return - Total\ investment)}{Total\ investment} \times 100$$

The individual profit of producer and wholesaler is calculated using the formula of described by Sajadieh and Jokag [12] and Goyal [11].

Without coordination:

The individual profit of the producer, retailer and distributor are given as,

Producer profit= 29.91%, Retailer profit= 12.28%, Distributor profit=19.59% and net profit= 61.78%.

With coordination:

When the value of $\beta 1$ is assumed and the problem is solved using the solution procedure, whose results are tabulated in Table 1.

Table1. Coordinated policy with various shortage recovering

S. No.	$\beta 1$	Producer profit%	Retailer profit%	Distributor profit%	Net profit%
1	0.01	**32.96**	23.42	**30.06**	**86.44**
2	0.03	30.91	25.99	34.43	91.33
3	0.05	29.70	27.42	36.95	94.07
4	0.07	28.92	28.45	38.60	95.97
5	0.09	28.35	29.20	39.75	97.30
6	0.10	28.14	29.50	40.21	97.85
7	0.30	26.40	31.95	43.79	102.14
8	0.50	29.98	32.68	44.74	103.39
9	0.70	29.73	32.97	45.18	103.88
10	1.00	**25.55**	33.21	**45.52**	**104.28**

The result shows that maximum profit is obtained for the coordinate policy when $\beta 1 = 1$ that is for complete outsourcing, even though the producer profit decrease. Therefore it has become possible to outsource the entire shortage beneficially. It is also observed that as the value of $\beta 1$ is increased the coordinated benefit is also increased.

Results of the different market players of the supply chain network are shown in Table 2.

Table 2: Results of the different market players

Market players	Profit% after coordination	Profit% before coordination	Compare with respect to non-coordinate model (percentage)
Distributor	45.52	19.59	25.93
Retailer	33.21	12.28	20.93
Producer	**25.55**	**29.91**	-4.36
Coordinated benefit	**104.28**	**61.78**	42.50

The observable decrease of the producer may be totally makeup by the retailer and distributor big profit and hence the system of coordination profit 42.50% with shortfall totally recovering. According to the coordinated contract, these benefit shearing with each other. Therefore, after coordination for fully recovering of shortages, the coordinated benefit is increased by 42.50%.

Results of the different market players of the supply chain network are shown in Table 3.

Table 3: Results of the different market players

Market players	Coordination profit% with totally shortfall recovering	Coordination profit% without recovering of shortfall	Compare with respect to non-coordinate model (percentage)
Distributor	45.52	26.41	19.11
Retailer	33.21	21.52	11.69
Producer	**25.55**	**34.66**	-9.11
Coordinated benefit	**104.28**	**82.59**	21.69

The observable decrease of the producer may be totally makeup by the retailer and distributor big profit and hence the system of coordination profit 21.69% with shortfall without recovering. According to the coordinated contract, these benefit shearing with each other.

Fig.2, shows that the profit before and after coordination for various market players in the relevant field. At first time, the producer profit increase in coordination method without recovering of shortfall, but decrease with fully shortage recovering. In the same time the total profit increase after coordination for both cases without and with recovering of shortfall may be totally decreased by the retailer and distributor big profit.

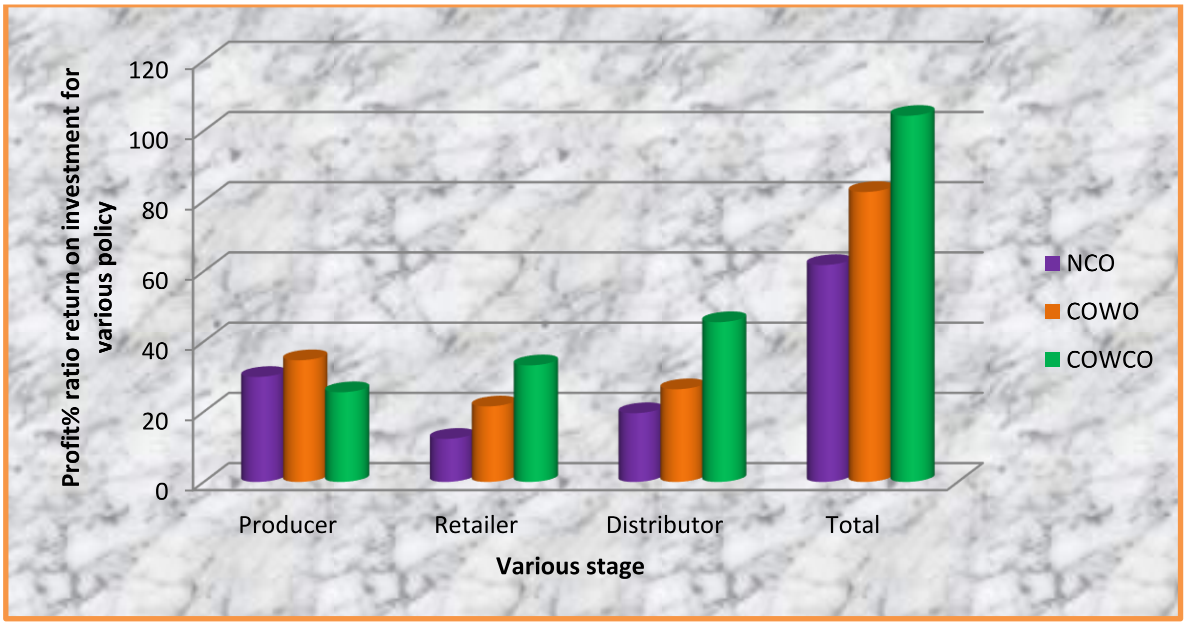

Fig.2 Profit of various market players before and after coordination

Therefore, coordination policy is the best policy for stable situation of agricultural sector in Bangladesh.

Sensitivity analysis was performed on the supply chain coordination model with supply and demand that uses the joint pricing policy. Decision variables were kept constant at the optimal level. Profit sensitivity to the supply and demand, when demand was fixed and supply was increased then profit increased (Fig.3), in this case supply is not greater than demand. On the other hand, when demand decrease and supply increase then profit decrease (Fig.4). Therefore, for supply chain coordination policy, each market players must have to satisfy their supply-demand condition.

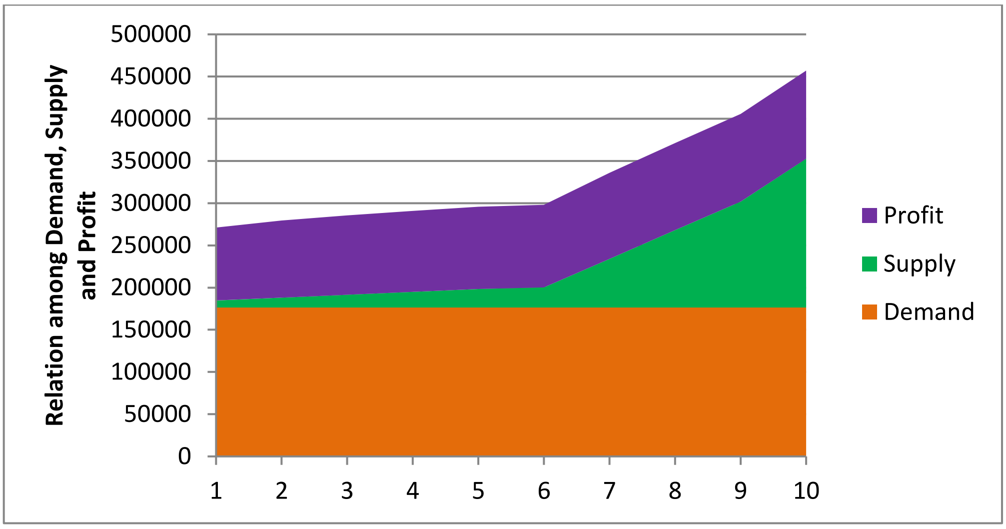

Fig.3 Profit sensitivity between supply demands

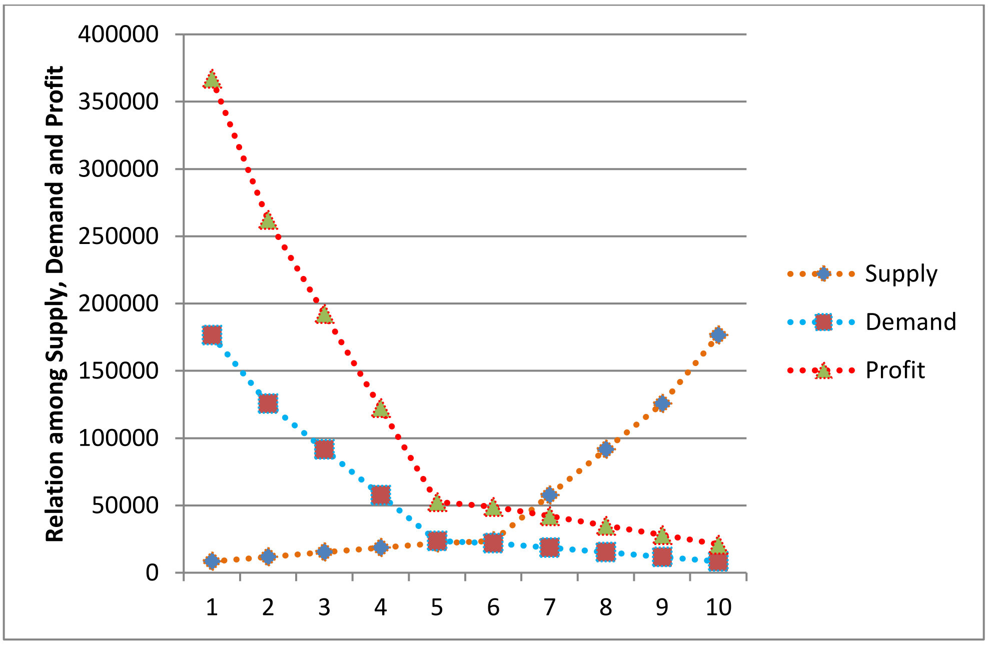

Fig.4 Profit sensitivity between supply demands

CONCLUSIONS

In this research, four mathematical MILP based models are developed for the coordinated SCN and solved these models by using AMPL with appropriate solver MINOS. In this paper, we assumed the insufficient production capacity of the producer as the reason for shortages; it has been shown that total coordinated profit may be improved by totally recovering of shortfall. The formulated models simultaneously maximize the profit. Some of the significance findings can be summarized as follows:

The illustrated numerical example shows that maximum profit is obtained for the coordinate policy when $\beta 1 = 1$ that is for total recovering by external sources. The observable loss of the producer may be recovered by the retailer and distributor big profit and hence the system of coordination benefits 42.50% with fully shortfall recovering by external sources and shared these benefit according to the coordinated condition. Therefore, after coordination for total shortages recovering by external sources, the coordinated benefit is increased by 42.50%. It is also observed that as the value of $\beta 1$ is increased the coordinated benefit is also increased. Hence, after coordination for total shortfall recovering, the coordinated benefit is increased by 21.69% according to without recovering of shortfall. These benefit, shared to each other according to the coordinated agreement. On the other hand, for stable situation the relation of supply and demand is very important.

The work may also be expanded along a more progressive environment considering production and demand uncertainty.

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References

Ganeshan R., Harrison T.P., An introduction to supply chain management - http://silmaril.smeal.psu.edu/misc/supply_chain_intro.html, 1995.

Pourakbar, M., Farahani, R. Z. and Asgari, N. A joint economic lot-size model for an integrated supply network using genetic algorithm, Applied Mathematics and Computation, Vol. 189, 2007, pp. 583-596.

Brandenburg, M. et al. Quantitative models for sustainable supply chain management: Developments and directions. European Journal of Operational Research, Vol. 233, 2014, pp. 299–312.

Nickel, S., Saldanha-da-Gama, F. & Ziegler, H.P. A multi-stage stochastic supply network design problem with financial decisions and risk management. Omega, Vol. 40, 2012, pp. 511–524.

Papageorgiou, L.G. Supply chain optimization for the process industries: Advances and opportunities. Computers and Chemical Engineering, Vol. 33, 2009, pp. 1931–1938.

Ahumada, O. & Villalobos, J.R. A tactical model for planning the production and distribution of fresh produce. Annals of Operations Research, Vol. 190, 2011, pp. 339–358.

Rong, A., Akkerman, R. & Grunow, M., An optimization approaches for managing fresh food quality throughout the supply chain. International Journal of Production Economics, Vol. 131, 2011, pp. 421–429.

Aung, M.M. & Chang, Y.S. Traceability in a food supply chain: Safety and quality perspectives. Food Control, Vol. 39, 2014, pp. 172–184.

Vander Vorst, J., Tromp, S.-O. & Zee, D.-J. Vander Simulation modeling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics. International Journal of Production Research, Vol. 47, 2009, pp. 6611–6631.

Shukla, M. & Jharkharia, S. Agri-fresh produce supply chain management: a state-ofthe-art literature review. International Journal of Operations & Production Management, Vol. 33, 2013, pp. 114–158.

Goyal, S.K. An integrated inventory model for a Single supplier-single customer problem, International Journal of Production Research, Vol. 15(1), 1976, pp.107-111.

Sajadieh, M.S. and Jokar, M.R.A. Optimizing shipment, ordering and pricing policies in a two stage supply chain with price sensitive demand, Transportation Research Part E, Vol. 45, 2009, pp.564- 571.

Drezner, Z., and Hamacher, H. (eds.) Facility Location: Applications and Theory, Springer Verlag, Berlin, 2002.

Hung, B., and Liu, N. Bilevel programming approach to optimizing a logistic distribution network with balancing requirements, Transportation Research Record: Journal of the Transportation Research Board, Vol. 1894, 2004, pp.188-197.

Jose, C. S., Haider, A. B., Rui, B., and Alexandre, S. A multi objective approach to solve capacitated vehicles routing problems with time windows using mixed integer linear programming, International Journal of Advanced Science and Technology, Vol. 28, 2011, pp. 1-8.

Yamada, T., Imai, K., Nakamura, T., and Taniguchi, E. Supply chain-transport super network equilibrium model with the behavior of freight carriers, Transportation Research Part E: Logistics and Transportation Review, Vol. 47(6), 2011, pp. 887–907.