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MODELING AND OPTIMIZATION OF MULTI-LAYER AGGREGATE PRODUCTION PLANNING

ABSTRACT

Aggregate production planning has attracted the attention of researchers for quite a long time now; and the continued researches depict the significance and scope for improvement in this arena. Here, a multi-product, multi-level and multi-period model has been formulated to identify the required aggregate plan for meeting the forecast demand, by regulating production rates, inventory, workforce, various production costs, and other controllable variables. Several new contributing factors, such as costs related to material handling, raw material inventory and worker training have been included in the objective function and constraint equations to make the model more realistic. A case study has been presented for a cosmetics and toiletries manufacturer in Bangladesh. Eventually, the problem has been solved using Genetic Algorithm and Particle Swarm Optimization approach. The solution illustrates that the model can be applied in a real world scenario to enhance productivity and profitability.

KEYWORDS | Aggregate production planning, inventory optimization, multi-period modeling, genetic algorithm, particle swarm optimization.

Ridwan Al Aziz
ridwan_rivan@yahoo.com

Himangshu Kumar Paul
hemen01@ymail.com

Touseef Mashrurul Karim
touseefkarim@gmail.com

Imtiaz Ahmed
imtiaz_avi@yahoo.com

Abdullahil Azeem
azeem@ipe.buet.ac.bd

Bangladesh University of Engineering & Technology, Dhaka, Bangladesh

INTRODUCTION

Aggregate production planning (APP) is a process that incorporates forecast of usually 3 months to 18 months, known as the medium range forecast. It focuses on the determination of production, inventory and workforce levels while meeting the fluctuating demands requirement. The planning horizon usually sets the next seasonal peak in demand as the target and assumes the physical resources of the firm deterministic and constant. Aggregating the information being processed becomes a must for a long planning horizon. Once the APP is established, constraints are imposed on the production process. Adhering to an APP model can help businesses operate in a leaner manner. It increases production rate significantly by maximizing the utilization of production equipment and allows for contingency measures so that firms can better accommodate the uncertainties in customer orders and production. That's why; it has always been of immense significance to formulate the APP model as realistic as possible.

Baykasoglu (2001) has presented APP as a midterm planning for capacity to regulate the production, workforce and inventory levels for a given set of constraints. A good number of practitioners and academia (Shi & Haase, 1996) has been carrying out intriguing researches on APP resulting different APP models with varying degree of sophistication in past few years. Holt, Modigliani, and Simon (1955) proposed the approach to solve APP model for the first time. Hanssmann and Hess (1960) developed linear programming model which was extended for multi-product and multi-stage production systems by Haehling (1970). Masud and Hwang (1980) introduced goal programming (GP), the step method and sequential multi-objective problem to solve APP problem. Jain and Palekar (2005) presented comparison among several heuristics by solving the aggregate production planning problem using the configuration-based formulation. Entezaminia, Heydari, and Rahmani (2016) proposed a multi objective APP model for a multi-period multi-site scenario considering green and reverse logistics. Al-e-hashem, Malekly, and Aryanezhad (2011) tackled a multi-period and multi-product APP model under uncertainty by applying LP-metrics method. Leung, Wu, and Lai (2017) presented a stochastic programming approach for addressing the uncertainty in a multi-site aggregate production planning.

Tsoulos (2009) presented Genetic Algorithm (GA) for constrained optimization model, whereas Bunnag and Sun (2005) presented a stochastic optimization method to solve constrained optimization problems over a compact search domain. Fahimnia, Luong, and Marian (2008) presented a methodology to model the Aggregate Production Planning problem, which is combinatorial in nature, when optimized with Genetic Algorithms. Konak, Coit, and Smith (2006) gave an overview and tutorial on genetic algorithm for multi-objective optimization. Eldos (2005) introduced a new topology independent scheme called the selective migration model in genetic algorithm. Ramezanian, Rahmani, and Barzinpour (2012) developed a mixed integer linear programming (MILP) addressing NP-hard class of APP, and implemented GA and tabu search for solving that problem. The mixed integer programming was implemented by Hung and Hu (1998) who considered maximizing revenue along with minimizing inventory and cost. Artificial intelligence approaches, sometimes including mathematical programming models have been used for solving APP models. Khalili-Damghani and Shahrokh (2014) solved a multi-objective multi-period multi-product APP problem using Fuzzy Goal Programming. The hybrid discrete event simulation (DES) and system dynamics (SD) methodology were introduced in the APP field by Jamalnia and Feili (2013).

Particle Swarm Optimization (PSO) has been applied to an array of applications which can generate good solutions with small calculation time and stable convergence. Eberhart and Kennedy (1995) introduced particle swarm methodology for optimization of nonlinear functions. Wang, Liu, Zeng, Li, and Li (2007) showed an opposition-based learning scheme to PSO (OPSO) along with a Cauchy mutation results in a better convergence. Lei (2008) applied a pareto archive particle swarm optimization for multi-objective job shop scheduling, whereas Chen (2011) introduced a two-layer particle swarm optimization (TLPSO) model. Later Wang, Sun, Li, Rahnamayan, and Pan (2013) modified the PSO algorithm by incorporating the idea of sub-particles. It produced a better search process than the general PSO.

However, the previous studies failed to incorporate some factors like costs related to material handling, raw material inventory and worker training; which undoubtedly shapes the APP model of a firm in a great way. So by considering the factors and constraints associated with these cost terms, the proposed APP model will become one step closer to the real scenario and will guide the firms in a more accurate fashion. And unlike many papers, instead of just

minimizing the total production cost, this study has considered minimizing the total production loss as it also incorporates the effects of sales revenue.

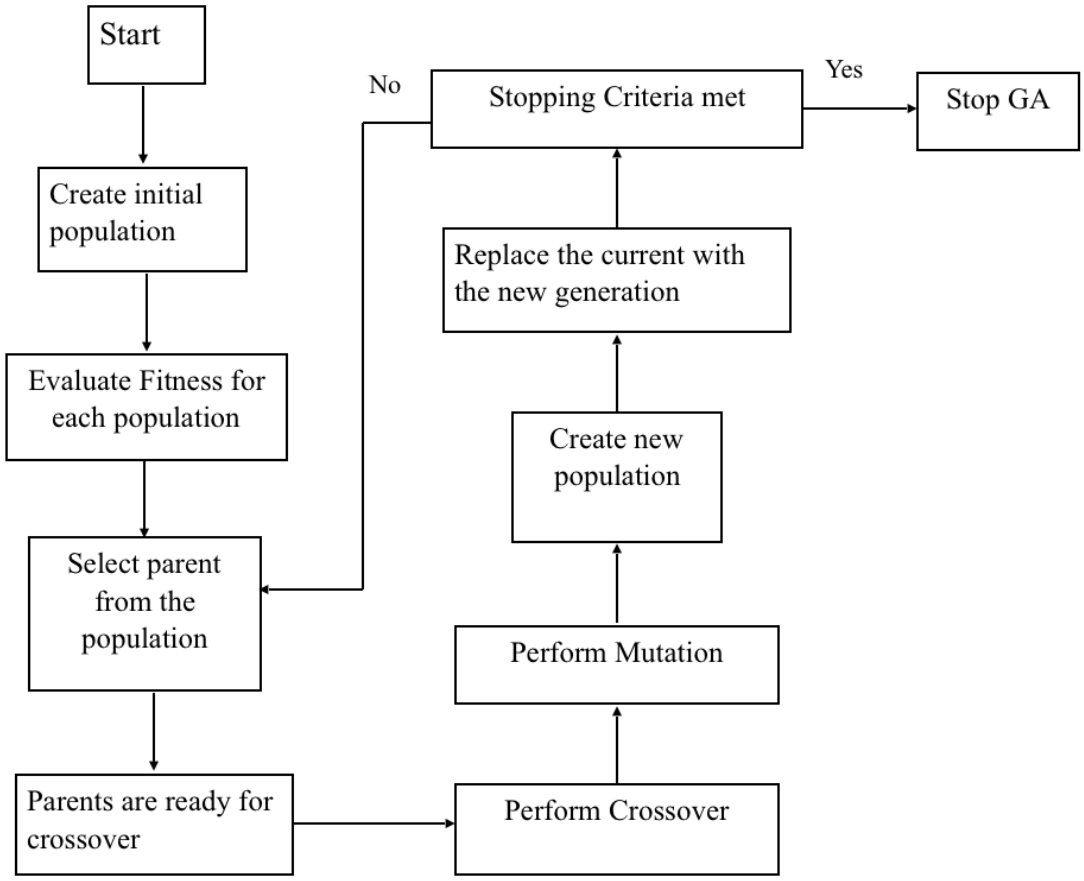
The rest of this paper is organized as follows. The proposed model is formulated and described in details with assumptions first. Then the model is implemented in a case study where GA and PSO are used. After presenting and explaining he results and findings, the paper concludes with some specific directions for future research in this arena.

THEORETICAL FRAMEWORK

Genetic Algorithm

A genetic algorithm is a problem solving method that uses genetics as its model of problem solving. It is a search technique to find approximate solutions to optimization and search problems. The basic of genetic algorithm is shown in Figure 1.

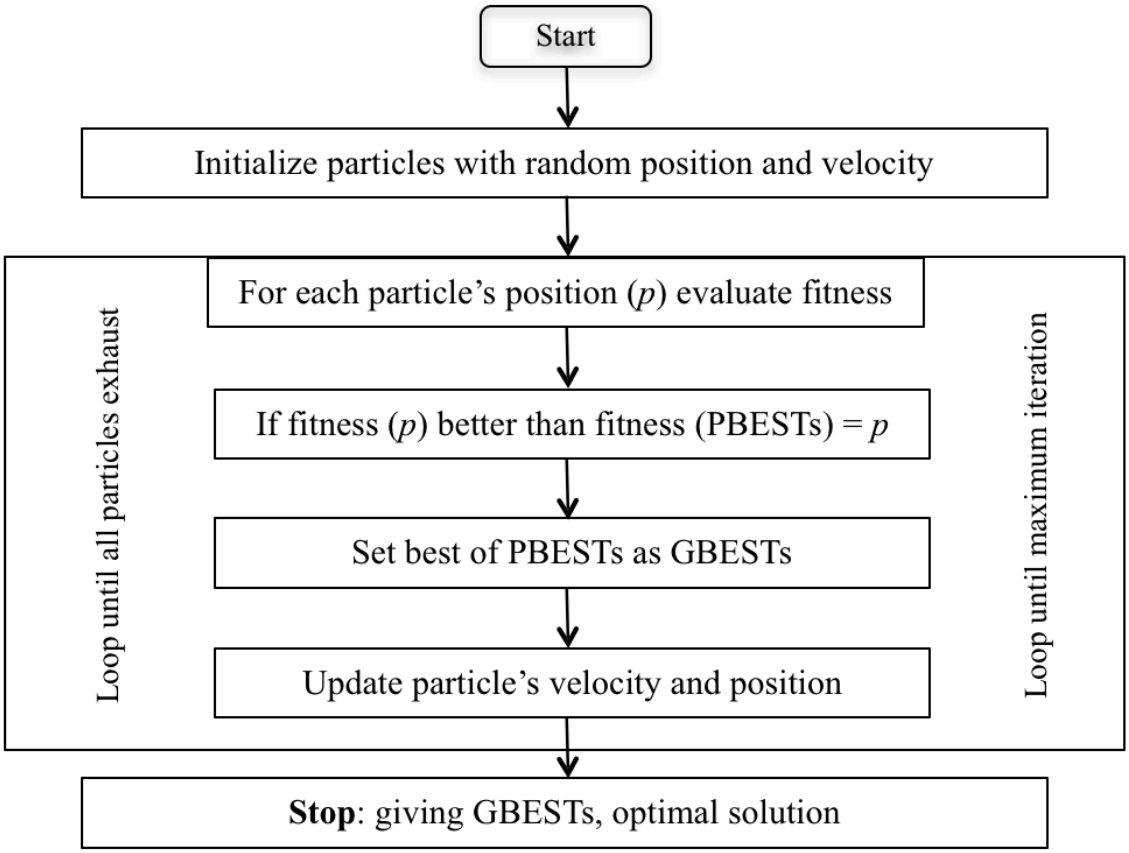
Figure 1: Outline of Genetic Algorithm



Particle Swarm Optimization (PSO) Algorithm

We have developed a PSO model for the relevant objective function and constraint equations, similar to the single objective GA model. The main purpose of this research work is to develop a fair comparison among these two models with the same set of considerations. The basic of PSO is illustrated in Figure 2.

Figure 2: Outline of PSO Algorithm



The APP Model Formulation

The mathematical model is based on the following assumptions:

1. Products are independent to each other, related to marketing and sales price.

2. All per unit costs and set up costs are considered constant for a given period.

3. Backorders are considered.

4. Shortage cost is not considered.

5. Hiring presumes an available supply of workers.

6. Backorder quantity of previous month is completed first in the current month and then the planned production of this month is commenced. So the production of backorder quantity is usually carried out in the regular production time.

7. The penalty of the backordered quantity for the j period is included in that months cost of Aggregate Production Planning.

8. Demand is continuous.

9. Workers hired in a certain period will not be laid off in the same period.

10. The manufacturer sets the wholesale price (while there is still uncertainty regarding demand), and the retailer orders product. The units are produced and delivered to the retailer.

11. The retailer takes delivery of ordered units when demand is still unknown and assumes ownership upon delivery.

12. Each worker is assigned for a particular line of product.

The following notations are used after reviewing the literature and considering practical situations:

P_{ijk} = Regular time production cost per unit of i^{th} (type of product) product in period j for k level (casual, temporary, permanent) workers (Tk./unit/minute)

a_{ijk} = Regular time quantity of i^{th} product in period j for k level workers (units)

α_{ijk} = Required time for regular time production per unit of i^{th} product in period j for k level workers (minutes)

O_{ijk} = Overtime production cost per unit of i^{th} product in period j for k level workers (Tk./unit/minute)

b_{ijk} = Overtime quantity of i^{th} product in period j for k level workers (units)

β_{ijk} = Required time for overtime production per unit of i^{th} product in period j for k level workers (minutes)

SC_{ij} = Subcontracting cost per unit of i^{th} product in period j (Tk./unit/minute)

d_{ij} = Subcontracting quantity of i^{th} product in period j (units)

γ_{ij} = Required time for production in subcontract per unit of i^{th} product in period j (minutes)

IR_{zj} = Inventory carrying cost per unit of z^{th} (type of raw material) raw material in period j (Tk./unit)

e_{zj} = Inventory level of z^{th} raw material in period j (units)

IF_{ij} = Inventory carrying cost per unit of i^{th} product in period j (Tk./unit)

f_{ij} = Inventory level of i^{th} product in period j (units)

B_{ij} = Backorder cost per unit of i^{th} product in period j (Tk./unit)

g_{ijk} = Backorder quantity of i^{th} product in period j for k level workers (units)

Y_{zj} = Material handling cost per unit of z^{th} raw material in period j (Tk./unit/minute)

r_{zj} = Material handling quantity of z^{th} raw material in period j (units)

π_{zj} = Material handling time per unit of z^{th} raw material in period j (minutes)

M_{ij} = Material handling cost per unit of i^{th} product in period j (Tk./unit/minute)

n_{ij} = Material handling quantity of i^{th} product in period j (units)

δ_{ij} = Material handling time per unit of i^{th} product in period j (minutes)

H_{ijk} = Hiring cost per labor of k level for i^{th} product in period j (Tk./labor)

h_{ijk} = No. of labor of k level hired for i^{th} product in period j (no. of labor)

F_{ijk} = Firing cost per labor of k level for i^{th} product in period j (Tk./labor)

l_{ijk} = No. of labor of k level fired for i^{th} product in period j (no. of labor)

T_{ijk} = Training cost per labor of k level for i^{th} product in period j (Tk./labor)

m_{ijk} = No. of labor of k level to be trained for i^{th} product in period j (no. of labor)

m_{ijkk} = No. of labor of k level to be trained to k′ level for i^{th} product in period j (no. of labor)

S_{ij} = Sale price per unit of i^{th} product in period j (Tk./unit)

v_{ij} = Sale quantity of i^{th} product in period j (units)

ATR_{ijk} = Available time for regular production of i^{th} product in period j for k level workers (minutes)

ATO_{ijk} = Available time for overtime production of i^{th} product in period j for k level workers (minutes)

ATS_{ij} = Available time for subcontracting of i^{th} product in period j (minutes)

MU_{ijk} = Machine usage per unit of i^{th} product in period j for k level workers (machine-hours)

MMC_{ij} = Machine capacity for i^{th} product in period j (machine-hours)

WSR_{zj} = Warehouse space required for one unit of z^{th} raw material in period j (cubic feet)

WSR_{ij} = Warehouse space required for one unit of i^{th} product in period j (cubic feet)

$MWCR_{j}$ = Warehouse capacity for raw materials in period j (cubic feet)

$MWCF_{j}$ = Warehouse capacity for finished products in period j (cubic feet)

ν_{k} = Productivity of k level labor ($0 \leq \leq 1$)

SUP_{zj} = Quantity of z^{th} raw material in period j from suppliers (units)

μ_{zij} = Quantity of z^{th} raw material required for one unit of i^{th} product in period j (units)

L_{ijk} = No. of k level labor required for producing one unit of i^{th} product in period j

ω_{j}= Fraction of labor variation allowed in period j

The objective function includes production costs such as regular time production, overtime, subcontracts, inventory cost of raw materials and finished goods, backordering and material handling. The second portion of the objective function includes the cost of changing the labor levels, such as hiring, laying-off and training workers. Finally, the forecasted sales revenue has been deducted from these costs, and our objective is to minimize this difference. The factors that we have introduced in this objective function include segregating the raw materials and finished goods, material handling and training cost. We have tried to minimize the loss (i.e. maximizing the profit) by incorporating the sales revenue, while the other papers have tried to minimize the cost of production.

The objective function of the proposed model can be derived as follows:

Minimizing Total Loss = (Regular Time Production Cost) + (Overtime Production Cost) + (Subcontracting Cost) + (Inventory Cost of Raw Materials and Finished Goods) + (Backordering Cost) + (Material Handling Cost) + (Labor Hiring, Laying-off and Training Cost) – (Forecasted Sales Revenue)

$$\text{Regular time production cost} = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[P_{ijk}a_{ijk}\alpha_{ijk}\right]$$

This cost includes direct material, direct labor, manufacturing overhead, administrative and marketing or selling cost.

$$\text{Overtime Production Cost} = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[O_{ijk}b_{ijk}\beta_{ijk}\right]$$

Overtime Production Cost includes direct material, overtime labor, manufacturing overhead, administrative and marketing or selling cost.

$$\text{Subcontracting Cost} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left[SC_{ij}d_{ij}\gamma_{ij}\right]$$

This cost includes the cost of materials provided by the manufacturer to the subcontractor, and the rate that will be charged for producing the products by the subcontractor.

$$\text{Inventory Cost of Raw Materials and Finished Goods} = \sum_{z=1}^{Z}\sum_{j=1}^{J}\left[IR_{zj}e_{zj}\right] + \sum_{i=1}^{I}\sum_{j=1}^{J}\left[IF_{ij}f_{ij}\right]$$

This cost includes holding or carrying cost and ordering cost. Holding cost includes insurance, depreciation, spoilage, breakage, warehousing costs (heat, light, rent, security) etc.

$$\text{Backordering Cost} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left[B_{ij}\sum_{k=1}^{K}\left[g_{ijk}\right]\right] + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[P_{ijk}g_{i(j-1)k}\alpha_{ijk}\right]$$

This cost includes the penalty that the manufacturer has to pay for not being able to supply the product on time according to the demand and the cost of production in the current period to produce the backordered quantity of the previous period.

$$\text{Material Handling Cost} = \sum_{z=1}^{Z}\sum_{j=1}^{J}\left[Y_{zj}r_{zj}\pi_{zj}\right] + \sum_{i=1}^{I}\sum_{j=1}^{J}\left[M_{ij}n_{ij}\delta_{ij}\right]$$

This cost refers to the cost related to labor and equipment for loading, unloading, palletizing, depalletizing, unitizing, packaging, etc. for handling materials.

$$\text{Labor Hiring, Firing and Training Cost} = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[H_{ijk}h_{ijk} + F_{ijk}l_{ijk} + T_{ijk}m_{ijk}\right]$$

Hiring cost includes recruitment, screening and training. Quality may also suffer, whereas firing cost includes severance pay, the cost of readjusting workforce, lack of goodwill towards the farm on the part of fired workers, and loss of morale for remaining workers. Training cost includes the costs to bring new workers up to speed as well as training of the existing workers to increase their skill and expertise.

$$\text{Forecasted Sales Revenue} = \sum_{i=1}^{I}\sum_{j=1}^{J}\left[S_{ij}v_{ij}\right]$$

This includes the selling price that the manufacturer will charge to the customer and the forecasted demand.

So, the objective function can be expressed as follows:

$$\text{Min } X = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[P_{ijk}a_{ijk}\alpha_{ijk} + O_{ijk}b_{ijk}\beta_{ijk} + P_{ijk}g_{i(j-1)k}\alpha_{ijk}\right] +$$

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\left[SC_{ij}d_{ij}\gamma_{ij} + IF_{ij}f_{ij} + B_{ij}\sum_{k=1}^{K}\left[g_{ijk}\right] + M_{ij}n_{ij}\delta_{ij}\right] +$$

$$\sum_{z=1}^{Z}\sum_{j=1}^{J}\left[IR_{zj}e_{zj} + Y_{zj}r_{zj}\pi_{zj}\right] + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\left[H_{ijk}h_{ijk} + F_{ijk}l_{ijk} + T_{ijk}m_{ijk}\right] -$$

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\left[S_{ij}v_{ij}\right] \quad (1)$$

Where, X = Total loss

Functional Constraints:

Constraint Equations for Inventory:

$$f_{i(j-1)} + \sum_{k=1}^{K}\left[a_{ijk} + b_{ijk} - g_{ijk} + g_{i(j-1)k}\right] + d_{ij} - f_{ij} = v_{ij}$$

(2)

The forecasted demand v_{ij} consists of inventory level of finished goods of the previous period, as well as regular and overtime production, backorder and subcontracting. The backorder of previous period and the finished goods inventory of this period are then subsequently deducted to determine the forecasted sales quantity. Backorder of a previous period must be fulfilled in the next period.

$$e_{zj} \le e_{z(j-1)} + SUP_{zj} - \mu_{zij}\sum_{k=1}^{K}\left[a_{ijk} + b_{ijk} + g_{i(j-1)k}\right] \quad (3)$$

The raw materials available from the previous period plus the quantity received from suppliers in this period less the usage of raw materials for regular, overtime and backorder production in this period should be equal to the inventory at the end of this period.

Constraint Equations for Labor:

$$L_{i(j-1)k}\left[a_{i(j-1)k} + b_{i(j-1)k} + g_{i(j-2)k}\right] + h_{ijk} - l_{ijk} - L_{ijk}$$

$$\left[a_{ijk} + b_{ijk} + g_{i(j-1)k}\right] - m_{ijkk''} + \quad (4)$$

The number of labor at a certain level in this period is equal to the labor in the previous period plus the workers who were hired and from this the number of workers laid off is subtracted. Also the workers who were upgraded from a lower level are added and the workers who were transferred from this current level to a superior level are subtracted.

$$\sum_{i=1}^{I}\sum_{k=1}^{K}\left[h_{ijk} + l_{ijk}\right] \le \omega_{j-1}\sum_{i=1}^{I}\sum_{k=1}^{K}L_{i(j-1)k}\left[a_{i(j-1)k} + b_{i(j-1)k} + g_{i(j-2)k}\right]$$

(5)

The number of workers in the previous period determines how many people can be hired and laid off in the current period. This number should be less than or equal to a certain percentage of the labor level of the previous period, which will be determined by the company labor policy.

$$l_{ijk} + \sum_{k''=1}^{K} m_{ijkk''} \le L_{i(j-1)k}\left[a_{i(j-1)k} + b_{i(j-1)k} + g_{i(j-2)k}\right]$$

(6)

The number of workers who can be laid off or upgraded to a higher level in this period should be less than or equal to the number of workers in the previous period.

$$\sum_{k=1}^{K}\nu_k\left[ATR_{ijk} + ATO_{ijk}\right] \ge \sum_{k=1}^{K}\left[a_{ijk}\alpha_{ijk} + b_{ijk}\beta_{ijk} + g_{i(j-1)k}\alpha_{ijk}\right]$$

(7)

The number of labor hours available through regular and overtime must be greater than or equal to the time required for outputs at regular, overtime and backorder production.

Constraint Equations for Warehouse Capacity:

$$\sum_{z=1}^{Z}\left[WSR_{zj}e_{zj}\right] \le MWCR_j \quad (8)$$

This equation denotes that the space required for

the inventory of raw materials should be less than or equal to the warehouse capacity of raw materials in each period.

$$\sum_{i=1}^{I} \left[WSF_{ij} f_{ij} \right] \leq MWCF_j \quad (9)$$

This equation denotes that the space required for the inventory of finished goods should be less than or equal to the warehouse capacity of finished goods in each period.

Constraint Equation for Machine Capacity:

$$\sum_{k=1}^{K} MU_{ijk} \left[a_{ijk} + b_{ijk} + g_{i(j-1)k} \right] \leq MMC_{ij} \quad (10)$$

This equation represents the limits of actual machine capacity. That is, the machine usage for regular, overtime and backorder production must be less than or equal to the machine capacity for a certain period.

Constraint Equation for Subcontracting:

$$d_{ij} \gamma_{ij} \leq ATS_{ij} \quad (11)$$

The time required for subcontracting in each period should be less than or equal to the time available at the subcontractors' facility.

Constraint Equations for Material Handling:

$$r_{zj} \leq SUP_{zj} + e_{z(j-1)} \quad (12)$$

This equation denotes that the quantity of raw materials handled in current period should be less than or equal to the amount of raw materials provided by suppliers in this period and inventory of raw materials in the previous period.

$$n_{ij} \leq a_{ijk} + b_{ijk} + g_{i(j-1)k} + f_{i(j-1)} \quad (13)$$

This equation denotes that the quantity of finished goods handled in current period should be less than or equal to the amount of goods produced in regular time and overtime in this period and inventory of finished goods in the previous period.

Non-negativity Constraints:

$$a_{ijk}, b_{ijk}, d_{ij}, e_{zj}, f_{ij}, g_{ijk}, n_{ij}, h_{ijk}, l_{ijk}, r_{zj}, m_{ijk} \geq 0 \text{ for all values of i, j, z and k} \quad (14)$$

MODEL IMPLEMENTATION

Case Description

Kohinoor Chemical Company (Bangladesh) Limited (KCCL) was used as a case study to demonstrate the practicality of the proposed methodology. This company was established in 1956. It is situated at Tejgaon Industrial Area, Dhaka. It is a pioneer manufacturing company in high quality beauty, toiletries and personal care products. A number of its brands such as Sandalina, Fast Wash, Genstar, Bactrol, Ice Cool and Fair & Care are renowned in Bangladesh. The brands Sandalina and Fast Wash have high demand in market, so they incur the most manufacturing resources and need to satisfy the customers within specified lead time. The major concentration of the study was focused on one Stock Keeping Unit (SKU) of each of the brands: 75-gram presentation of Sandalina soap (product 1) and 450 gram of Fast Wash (product 2). The planning horizon is 2 months long, namely September and October. Table 1, 2 and 3 summarize the information about products and raw materials for different periods and levels.

Table 1: Information about the Products, depending on the Period

Items	Product 1		Product 2	
	Period 1	Period 2	Period 1	Period 2
Forecasted Demand (units)	780000	760000	350000	360000
Subcontracting cost per unit (Tk./unit/min)	15.92	15.92	38.22	38.22
Required time for production in subcontract per unit (mins)	0.00011	0.00011	0.00025	0.00025
Inventory carrying cost per unit (Tk./unit)	0.16	0.16	0.382	0.382
Backorder cost per unit (Tk./unit)	1.2	1.2	2.6	2.6
Material handling cost per unit of finished product (Tk./unit/min)	0.477	0.477	1.15	1.15

(continue)

(conclusion)

Items	Product 1		Product 2	
	Period 1	Period 2	Period 1	Period 2
Material handling time per unit of finished product (mins)	0.0014	0.0014	0.002	0.002
Selling price per unit (Tk./unit)	24	24	52	52
Warehouse space required for one unit of finished product (cubic feet)	0.0068	0.0068	0.0246	0.0246
Machine capacity (machine hours)	630	630	420	420
Available time for subcontracting (mins)	210	210	210	210

Table 2: Information about the Products, depending on the Level

Items	Product 1						Product 2					
	Period 1			Period 2			Period 1			Period 2		
	Levels			Levels			Levels			Levels		
	1	2	3	1	2	3	1	2	3	1	2	3
Regular production cost (Tk./unit/min)	15.89	15.87	15.85	15.89	15.87	15.85	38.19	38.17	38.15	38.19	38.17	38.15
Regular time (mins)	0.007	0.0068	0.0066	0.007	0.0068	0.0066	0.01	0.098	0.096	0.01	0.098	0.096
Overtime production cost (Tk./unit/min)	20	19.5	19.2	20	19.5	19.2	49	48.7	48.3	49	48.7	48.3
Overtime (mins)	0.007	0.0068	0.0066	0.007	0.0068	0.0066	0.01	0.098	0.096	0.01	0.098	0.096
Hiring cost (Tk./labor)	5	0	0	5	0	0	5	0	0	5	0	0
Firing cost (Tk./labor)	100	120	150	100	120	150	100	120	150	100	120	150
Training cost (Tk./labor)	10	12	0	10	12	0	10	12	0	10	12	0
Number of labor	0.00094	0.00093	0.00092	0.00094	0.00093	0.00092	0.0013	0.0012	0.0011	0.0013	0.0012	0.0011
Number of labor to be trained	5	4	0	5	4	0	6	5	0	6	5	0
Labor productivity (%)	68	70	72	68	70	72	68	70	72	68	70	72
Available time for regular production (mins)	1800	1800	1800	1800	1800	1800	1200	1200	1200	1200	1200	1200
Available time for overtime (mins)	1800	1800	1800	1800	1800	1800	1200	1200	1200	1200	1200	1200
Machine usage (hours)	0	0	0.0001	0	0	0.0001	0	0	0.00023	0	0	0.00023

Table 3: Information about the Raw Materials

Items	Product 1				Product 2			
	Period 1		Period 2		Period 1		Period 2	
	RM 1	RM 2	RM 1	RM 2	RM 3	RM 4	RM 3	RM 4
Inventory Carrying cost per unit (Tk./unit)	0.00082	0.0142	0.00082	0.0142	0.00030	0.00010	0.00030	0.00010
Material handling cost of raw material per unit (Tk./unit/min)	2.46	42.7	2.46	42.7	0.92	0.31	0.92	0.31
Material handling time per unit (mins)	0.0014	0.0014	0.0014	0.0014	0.002	0.002	0.002	0.002
Quantity of raw materials from suppliers (gm)	292500000	4916667	292500000	4916667	333000000	204750000	333000000	204750000
Quantity of raw material per unit of product (gm)	73	1.3	73	1.3	167	103	167	103
Warehouse space for one unit of raw material (cubic feet)	0.0000542	0.000047	0.0000542	0.000047	0.000056	0.000035	0.000056	0.000035

Additional Information:

- Fraction of labor variation allowed according to labor union contracts and government regulations is 10%.
- Warehouse capacity for raw materials is 340 cubic feet.
- Warehouse capacity for finished products is 1000 cubic feet.

Genetic Algorithm Approach

The authors have used MATLAB computer software to solve the proposed model, using genetic algorithm approach for the KCCL case. Table 4 lists the values of the variables obtained by solving the model using GA by MATLAB.

Table 4(a): Calculated Multi-Product, Multi-Level and Multi-Period APP Plan

Items	Product 1						Product 2					
	Period 1			Period 2			Period 1			Period 2		
	Levels			Levels			Levels			Levels		
	1	2	3	1	2	3	1	2	3	1	2	3
Regular time quantity (units)	126667	126666	126666	84413	84413	84412	52000	52000	52000	50129	50130	50130
Overtime quantity (units)	86667	86668	86667	44413	44413	44412	34000	34000	34000	32130	32130	32130
Subcontracting quantity (units)	0			0			1			0		
Inventory level of finished product (units)	126762			20000			5610			5000		
Material handling quantity of finished product (units)	300000			300000			120000			120000		
No. of labor hired	0	0	0	0	0	1	0	0	0	0	1	0
No. of labor fired	0	0	0	0	0	1	0	0	0	0	0	0
No. of labor trained	0	0	0	2	0	2	0	0	0	0	0	1

Table 4(b): Calculated Multi-Product, Multi-Level and Multi-Period APP Plan

Items	RM 1		RM 2		RM 3		RM 4	
	P 1	P 2	P 1	P 2	P 1	P 2	P 1	P 2
Inventory level of raw material (units)	5000	5000	5000	5000	5000	5000	5000	5000
Material handling quantity of raw material (units)	3000000	500000	3000000	500000	3000000	2000000	3000000	2000000

Table 4(c): Calculated Multi-Product, Multi-Level and Multi-Period APP Plan

	Backorder Quantity (units)								
	Period 0			Period 1			Period 2		
	L 1	L 2	L 3	L 1	L 2	L 3	L 1	L 2	L 3
Product 1	86667	86666	86666	44413	44413	44413	1	0	1
Product 2	34000	34000	34000	32130	32130	32130	1	0	0

Table 5 illustrates the different GA parameters and options used to obtain the optimal value of the objective function. According to this calculation, the total profit for the two months taken into consideration comes to Tk. 35,47,000.

Table 5: Different GA Parameters and Options

GA Parameters	Options Used
Population Type	Double Vector
Population Size	20
Creation Function	Feasible Population
Fitness Scaling	Top
Selection Function	Roulette
Mutation Function	Adapt Feasible
Crossover Function	Heuristic
Migration	Both
Generations	60
Time Limit	Positive Infinity
Fitness Limit	Negative Infinity
Stall Time Limit	Positive Infinity
Iteration Needed to Complete	51

Particle Swarm Optimization Approach

Here in this research paper the authors proposed a particle swarm optimization model for solving this Aggregate Production Planning problem. Here for the initial run the cognitive coefficient C_1 is used as 0.5 and social coefficient C_2 is 1. A total of 20 particles are targeted and the stopping criterion is used as 100 loops or iterations. We have used MATLAB software for writing the program and solving the problem. For all the PSO variants the fitness value gives approximately similar values. It receives its minimum fitness or objective value Tk. 38,07,300 after 100 iterations. Table 5 illustrates the different PSO parameters and options used to obtain the optimal value of the objective function.

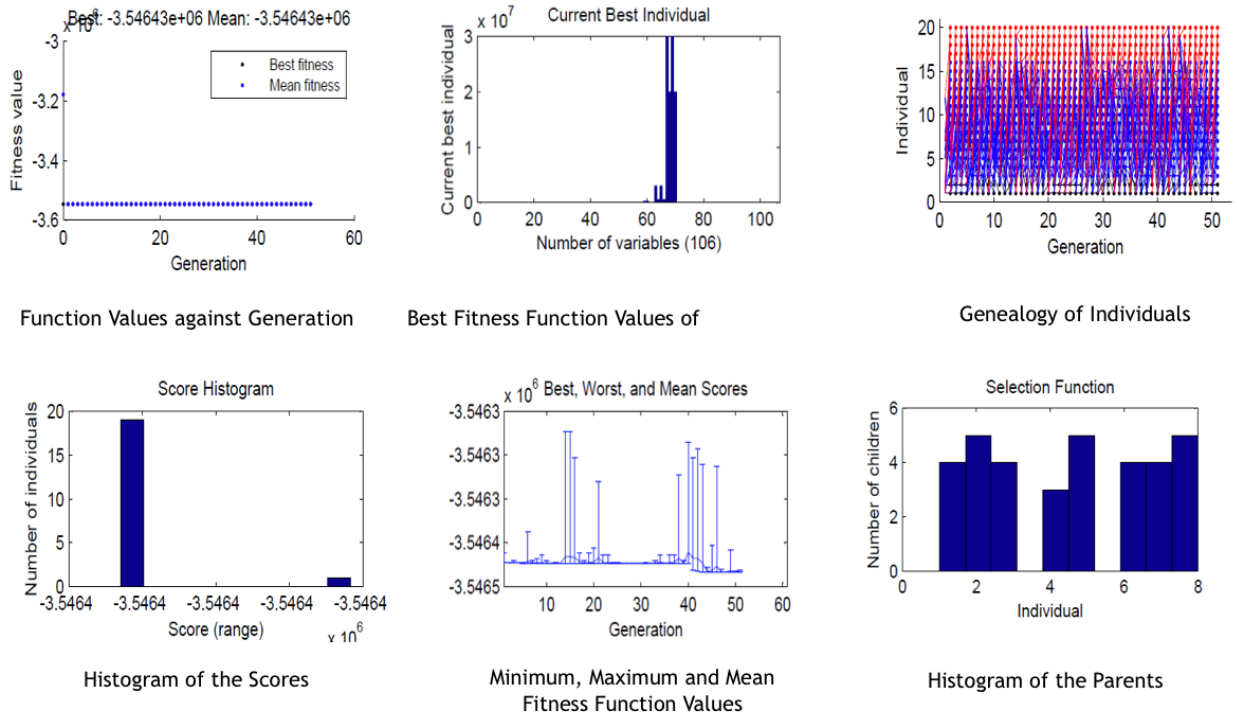
Table 6: Different PSO Algorithm Parameters and Options

PSO Parameters	Options Used
Population Size	20
Generations	100
Time Limit	Positive Infinity
Fitness Limit	Negative Infinity
Stall Time Limit	Positive Infinity
Stall Generations	50
Function Tolerance	1e-6
Constraint Tolerance	Negative Infinity

RESULTS AND FINDINGS

The solution developed by GA for the proposed single objective model is depicted in Figure-3.

Figure 3: Solutions by Genetic Algorithm



Both the GA and PSO approaches yield different fitness function values each time the program is run. This is because the initial population selection and steps in further iterations are done at random by these algorithms. So we have executed each of the algorithms 20 times for our proposed model, and then deduced a mean value for evaluation. Table 7 depicts the heuristic optima in each run by both GA and PSO algorithms. The actual net profit of Kohinoor Chemical Company (Bangladesh) Limited (KCCL) for the two months considered was around 3600000. The mean from PSO is Tk. 3547000 and from GA is Tk. 3807300. So the output from the PSO is closer to the actual value than the GA. The PSO also shows better performance in terms of standard deviation and range which are mentioned in Table 7.

Table 7: Heuristic Optima of Individual Run by GA and PSO Algorithm

Run	Heuristic Optima (Total Net Profit for 2 Months in Taka)	
	GA	PSO
1	3811531	3504100
2	3504826	3345649
3	3604915	3491658
4	3962154	3764212
5	3809562	3564974
6	3807300	3561974
7	3665482	3547000
8	3596215	3549167
9	3789652	3546196
10	3965882	3491673
11	3995145	3469167
12	3896325	3556798
13	3812654	3594361
14	3807300	3600945
15	3647589	3675485
16	3998798	3546197
17	4095789	3534697
18	3807300	3534645
19	3759784	3534596
20	3807800	3526497
Mean (Tk.)	**3807300**	**3547000**
Standard Deviation (Tk.)	**151741.6059**	**81089.46**
Range (Tk.)	**590963**	**418563**

The percentage difference between the two values is calculated as follows:

$$\text{Percentage difference} = \frac{\text{Difference of GA and PSO mean values}}{\text{Average of GA and PSO mean values}} \text{ x } 100\%$$

$$= \frac{3807300 - 3547000}{0.5 \text{ x } (3807300 + 3547000)} \text{ x } 100\%$$

$$= 7.1\%$$

Since the percentage difference between the two values is quite close, this indicates that, for multiple runs both GA and PSO provide similar solutions. The difference in runtime is also negligible. This depicts the validity of our proposed model, as well as the case study used for the numerical analysis.

Several new contributing factors, such as costs related to material handling, raw material inventory and worker training have been included in the objective function and constraint equations to make the model more realistic. Without incorporating these factors, the models provide solution over Tk. 4000000 which is further from our actual value of Tk. 3600000. This fact supports the validation of the model as these costs are actually incurred in practical scenario for the industries and thus incorporating these costs al-

lows KCCL to obtain a better solution. KCCL has already implemented this model and according to the response from the management of KCCL, they are obtaining more accurate and realistic solutions from this updated APP model.

CONCLUSION

Aggregate production planning (APP) is one of the most omnipresent but fluctuating problems in both the industry and academia. The battle to meet uncertain demands for different products in future as well as to decide hiring, firing, overtime, subcontract and carrying inventory level has always existed (Atiya et al., 2016). This research work presents a suitable approach for solving multi-product, multi-level and multi-period APP decision problems, with the forecast demand, related operating costs and capacity. The inclusion of variables such as material handling, labor training, raw material inventory, which have not been incorporated in other research works, has transformed the APP model to be more realistic. Finally, the PSO algorithm has been implemented in order to generate the optimal solution which is then again justified by implementing GA.

Future Recommendations

» Global optimum can be ensured by using a different fitness, crossover and migration functions, or utilizing different stopping criteria.

» Other than the factors that we have considered in this model, some other aspects can also be incorporated to enhance the accuracy of the model. These include shortage costs, availability of skilled workers, shortage of raw material supplies, etc.

» Cascade Rolling Horizon can be implemented with this model where the output of a certain number of period can be utilized as inputs for obtaining precise solutions for future periods.

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RUDIMENTARY CAUSES AND IMPACTS OF SUPPLY CHAIN RISKS IN SUB-SAHARAN AFRICA

ABSTRACT

Identification of the causes of supply chain risks is a logical step towards its effective management. The purpose of this study is to explore the causes of supply chain risks, their impacts, and the mitigating strategies used among the manufacturing firms in Nigeria. An exploratory qualitative multiple case research methodology combined with the quantitative content analysis is used for this study. A sample of ten manufacturing firms cutting across three different sub-sectors (Pharmaceutical & Health, Food & Beverage, and Conglomerate) was chosen for the study. Partial and complete open-ended questions in the interview guide were used for the interviews conducted among the respondents. The study revealed the common causes of supply chain risks in manufacturing firms in Nigeria which include; transportation delays, variation in raw material prices and quantities, unexpected customer demands, and constant power outages.

KEYWORDS | Supply chain risk, manufacturing firms, mitigation strategies, developing country context, case study.

Adenike Aderonke Moradeyo
adenike.moradeyo@augustineuniversity.edu.ng
Augustine University, Epe, Lagos State, Nigeria

INTRODUCTION

Several studies on sources of supply chain risks and risk management have gained popularity among academics over the years (Blackhurst, Craighead, Elkins, & Handsfield, 2005; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Stecke & Kumar, 2009; Kleindorfer & Saad, 2005; Tang, 2006). For the sake of emphasis, the majority of the recent works in operations management especially the supply chain management literatures are focussed on the developed countries such as Germany and USA (Ambulkar, Blackhurst, & Grawe, 2015; Robb, Xie, & Arthanari, 2008; Beske, Land, & Seuring, 2014; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Heckmann, Comes, & Nickel, 2015; Hofman, Busse, Bode, & Henke, 2014; Oke & Gopalakrishnan, 2009; Scheibe & Blackhurst, 2017; Tang, 2006; Wagner & Bode, 2006; 2008; Wiengarten, Humphreys, & Gimenez, 2016).

Notably, there are disparities in the types of supply chain risks experienced in developing and developed countries. Some environment-specific factors are the reasons for the differences in performance of manufacturing firms in developing and developed countries (Luken, Rompaey, & Zigova, 2008). Despite the effects of globalization on aligning the diverse markets in the developing and developed countries, there are still considerable differences in firms' performances (Onwubolu, Haupt, De Clerrcq & Visser, 1999).

Due to some environmental sources of disruptions as a result of geographical, technological, and infrastructural differences, there is the need to identify the causes of supply chain risks, the mitigation strategies used in managing different risks in manufacturing firms in developing countries, especially in the case of Nigeria. Nigeria is chosen as the developing context investigated. This is because Nigeria has become an important part of the global supply chain due to her large market in the Sub-Saharan Africa (Pigato & Tang, 2015).

The need for academic scholars and practitioners in Nigeria to focus on the Nigerian manufacturing sector in order to ensure notable improvement cannot be overemphasized. There is need to take advantage of the recent diversification from oil and the move away from the mono cultural activities in the country (Uzonwanne, 2015). It is also an important step towards attracting more foreign direct investments (FDIs) in the manufacturing sector in Nigeria and creating awareness for investors about potential risk factors in the country. The global interest in Africa at large and particularly, Nigeria has made this research work of great significance. This study focused on identifying and creating awareness about the causes of supply chain risks and supply chain risk management strategies popular to the developing context investigated. Hence, some sources of supply chain risks peculiar to manufacturing firms in Nigeria and the mitigation strategies commonly used in managing different supply chain risks have been identified. In addition, this work also enumerated the impacts of supply chain risks on the manufacturing firms in Nigeria.

As earlier explained, there has been a significant amount of research conducted in the area of supply chain systems among academics but there have been little or none reported on supply chain risk management in relation to the manufacturing sector in Nigeria. Therefore, this work focuses on typical manufacturing-oriented supply chains in Nigeria. The objectives of the study included are three. First, to identify and state the supply chain risks that disrupt the manufacturing operations of firms in a developing context. Second, to identify and state the impacts of supply chain risks on the operations of manufacturing firms in the developing context investigated. Finally, to identify and state the different mitigation strategies used by manufacturing firms in the developing context investigated without considering the fit or matching of supply chain risks with specific mitigation strategies. In this regard, the question answered in this study is " what is the state of the supply chain risks among the Nigerian manufacturing firms". The state of the supply chain risk from this context connotes its causes, impacts, and the different mitigating strategies used to manage the risks with no particular interest in the fit or matching perspectives in this study.

There have been growing research interests in supply chain risk management among scholars in the developed countries with less focus on the developing world's supply chain risk management and manufacturing processes. This gap necessitates the need to account for the developing countries' context in order to examine the peculiar attributes of the environment. Therefore, this study contributes the following to the supply chain risk management literature. First, it explores the phenomenon of supply chain risks emphasizing the root causes and impacts on manufacturing firms from a developing country's context. Second, it investigates and highlights the

different mitigating strategies for managing supply chain risks from a developing country context specifically, Nigeria with no focus on fit or matching dimensions. Hence, the scope of this research study does not include the matching of supply chain risks to their best mitigation strategies for managing them. Third, this study answers the call of making use of content analysis for research which is rarely used in the field of operations management and or supply chain management (Akkermans & Vos, 2013; Chatha, Butt & Tariq, 2015; Flynn, Sakakibara, Schroeder, Bates, Flynn, 1990; Meredith, 1993; Mir, Lu, Cantor, & Hofer, 2018; Turker & Altuntas, 2014).

The rest of this paper contains the following: section two is the literature review of this study. Section three presents the research methodology which comprises the instrument design, sample, data collection and analysis methods. Section four involves the research analysis and discussion and finally, Section five presents the summary of findings, contributions to the literature, areas for future research and limitations.

LITERATURE REVIEW

Supply Chain Risks

Supply chain risks are adverse events that could be anticipated or unanticipated with negative consequences on supply chains (Bode & Wagner, 2015; Hendricks & Singhal, 2003; Svensson, 2000; Tang & Musa, 2011). The utmost outcome of supply chain risk is the shortage of the number of goods produced and or supplied to customers compared to the amount demanded by customers. Moreover, unexpected occurrences that hamper the flow of goods or materials from reaching assigned destinations can also be referred to as supply chain risks (Hendricks & Singhal, 2003; Svensson, 2000). Some negative impacts of supply chain risks have been identified from the developed countries' contexts (Wagner & Bode, 2006). According to Porterfield, MacDonald and Griffis (2012), supply chain risks have negative effects on the stock market and operational performance. On a similar note, supply chain risks can directly affect corporate stock prices by nearly 9 per cent and revenue losses by 20 per cent (Benyoucef & Forzley, 2007). In addition, supply chain risks can have long-term negative effects on a firm's financial performance (Tang, 2006). The significant negative impact of supply chain risk on customers is that the disruption hinders the ability of producing firms from meeting customers' demands as at when due.

Academic scholars are often interested in risks, risk management strategies and their categorization over the years (Stecke & Kumar, 2009; Jüttner, 2005; Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005; Finch, 2004; Oke & Gopalakrishnan, 2009). According to Guedes, Bittar, Di Serio, and Oliveira (2015), risks are many and most commonly reported supply chain risks from the developed countries' contexts are supplier capacity not meeting demand, raw material price increase or shortages, unexpected changes in customer demand, delayed or damaged or misdirected shipments and fuel price increases or shortages. In addition to those mentioned above, there are terrorist attacks, strikes, devaluation of currencies, transportation delays such as port stoppages, accidents, poor communication, spare part shortages, quality issues, major global economic disruptions, natural hazards and cybersecurity failures (Blackhurst et al., 2005; Chopra & Sodhi, 2004; Finch, 2004; Jüttner, 2005; Kleindorfer & Saad, 2005; Stecke & Kumar, 2009; Tang, 2006; Worthington, Collins, & Hitt, 2009).

Hanna and Skipper (2009) in their work assert that supply chain risks cannot be avoided because all supply chains are exposed to risks. This study deviates from the norm by focussing on investigating the root causes and impacts of supply chain risks from a developing country context. Stecke and Kumar (2009), emphasized the need to pay attention to potential risk factors when moving manufacturing plants to developing countries' contexts in Africa and Asia because of the availability of low labour and materials costs. Tang (2006) classified such developing countries' contexts as turbulent environments. Hence, the importance of this study emanates from the evaluation of the causes of supply chain risks and the potential impacts on manufacturing firms from a developing country context in Africa. This supply chain risks evaluation cannot be underestimated.

Mitigation strategies

The efforts towards the management of supply chain risk involve the use of mitigation strategies. Mitigation strategies are defined as strategies put in place to manage anticipated and unanticipated risks in order to reduce or completely eliminate their negative impacts on supply chains (Norrman & Lindroth, 2004). Therefore, it is essential for firms to adopt risk mitigation strategies for managing supply chain risks in order to ensure smooth supply chain systems. Risk management process could be expensive, challenging,

and complex since there are different tiers in a supply chain cutting across the downstream and upstream stages (Bozarth, Warsing, Flynn & Flynn, 2009; Jüttner, 2005; Onwubolu, Haupt, Clercq, & Visser, 1999; Tang, 2006). However, the costs of not managing risks are higher (Benyoucef & Forzley, 2007; Macdonald & Griffis, 2012; Tang, 2006). The achievement of resilient manufacturing operations, cost minimisation and enhanced customer satisfaction are the outcomes of effective risk management strategies (Tang, 2006).

Extant works of literature have emphasized developed countries' contexts specific mitigation strategies. Several categorizations of risk management strategies and philosophies have been developed such as; robust strategies, proactive strategies, advance warning strategies, supply management strategies, demand management strategies, collaboration and co-operation philosophy, contingency tactics, distributed problem solving philosophy, information management strategies, supply chain agility philosophy, coping strategies, and product management strategies (Braunscheidel & Suresh, 2009; Beske et al., 2014; Chan & Chan, 2004; Stecke & Kumar, 2009; Rudberg & Olhager, 2003; Tang, 2006; Tang & Musa, 2011; Wiengarten et al., 2016; Tomlin, 2006). Specifically, some of these mitigation strategies are; postponement, strategic stock, flexible supply base / multiple sourcing, outsourcing, economic supply incentives, flexible transportation, revenue management, dynamic assortment planning, silent product rollover, safe locations and multiple facilities (Christopher & Lee, 2004; Blackhurst et al., 2005; Hanna & Skipper, 2009; Tang, 2006; Lee & Billington, 199; Johnson, 2001). All these studies were carried out in developed countries. Hence, the need to be aware of the mitigation strategies that are used by firms in the developing countries' contexts. The evaluation of the current mitigation strategies used by the manufacturing firms in Nigeria will establish if the strategies in use are adopted and adapted or created to suit the types of supply chain risks experienced. Therefore, this study hopes to bridge the research gap by concentrating on identifying supply chain risks and various mitigating strategies used to manage them from the Nigerian manufacturing perspective with no specific attention to the fit of risks with mitigation strategies.

Manufacturing in developing countries

According to Bozarth et.al. (2009), it is not the geographical location that influences the performance of a plant when compared with other plants but the suppliers' ability to deliver as at when due. In opposition to this view, Bruun and Mefford (1996) asserted that every production system should be tailored to its environment. For instance, just-in-time (JIT) production system may be inappropriate for developing countries because of certain environmental requirements (Oral, Mistikoglu, & Erdis, 2003). This may be partly because of low connectivity, poor information technology and the limited number of people trained to use such technology (Basu, 2004; Dada, 2006). According to Seuring & Müller (2008), in order to achieve a sustainable supply chain, both environmental and social factors should be put into consideration, albeit the ability to make profit is determined by being able to add value to customers consistently.

Some of the attributes of developing countries such as high inflation rate, high interest rate, high costs of technology, high costs of quality systems, low labour costs, high costs of training, high power distance culture, high uncertainty avoidance culture, few numbers of domestic suppliers among others (Oral, Mistikoglu, & Erdis, 2003). Consequently, these unique attributes of developing countries could have interaction effects with supply chain risks, thereby increasing the degree of severity of supply chain disruptions. Moreover, environmental risk sources are external conditions that impact the supply chains negatively such as political instability, macroeconomic uncertainties, shifts in government policies, social uncertainties and natural uncertainties (Jüttner, 2005; Miller, 1992; Miller, 1993; Rao & Goldsby, 2009). It has been found that political instability, macroeconomic uncertainties, shifts in government policies and social uncertainties are common attributes of most developing countries (Feng, 2001; Serven, 2002). Hence, the need to put these factors into consideration when adopting strategies from the developed country contexts.

Bruun and Meffford (1996) confirmed that little or no attention is given to the environment's unique attributes in developing countries in strategy adoption rather strategies are made to conform to those of other industrial countries. This depicts that despite the unique attributes of developing countries, strategies are adopted blindly with little or no consideration for the environmental implications. It is important for developing countries to imbibe research and development strategies that are creative and adapted to their specific business environments

(Kumar & Saqib, 1996). Oyelaran-Oyeyinka, Laditan & Esubiyi (1996) emphasized that the Nigerian industries have the adaptive innovation to account for the bulk of technological change processes. Whereas in actual sense, it is better for the Nigerian manufacturing companies to use creative mitigation tactics that are unique to the environment rather than adopting the tactics used for mitigating supply chain disruption in the developed world. This is because generally, the unique attributes of the developing countries (Jüttner, 2005) would have a way of increasing the severity of supply chain disruptions on firms' performance and the manufacturing sector as a whole.

RESEARCH METHODOLOGY

An exploratory qualitative research methodology, specifically multi-case study is used in this study. There were little or unknown research studies on supply chain risks and management in the developing countries' contexts literature. This necessitates the exploratory nature of the study and it is recommended in production and operations management (POM) research (Akkermans & Vos, 2013; Flynn et al. 1990; Meredith 1993). The case study method is an important research for exploratory qualitative research studies (Yin, 1989; Eisenhardt, 1989). A case study involves comprehensive and exhaustive analysis of respondents in their natural institutional and social work areas (Ghauri & Gronhaug, 2005). The choice of the qualitative research method is based on the purpose of the research, which is to carry out an in-depth study on supply chain risk and its management from the Nigerian manufacturing perspective. This qualitative research method accounted for the choice of a semi-structured interview, a purposive sampling technique and open-ended questions for data collection. Open-ended questions are provided in order to allow the supply chain managers or equivalent managers to express their thoughts without restraints. The use of face-to-face interview as the data gathering tool ensures clarity of responses from respondents through clarifications and detailed explanations (Forza, 2002; Saunders, Lewis, & Thornhill, 2003).

Some previous works on supply chain risks made use of the case study approach (Blackhurst et.al, 2005; Oke & Gopalakrishnan, 2009) where retail and automotive supply chains were the focus respectively. Gimenez (2005), on the other hand, used a multiple-method approach, that is, the survey and the case study methods (as complementary approaches) for investigating the SCM-performance relationship. Jüttner (2005) made use of the explorative quantitative survey method such as postal questionnaires along with a focus group for obtaining data from senior-level supply chain management professionals. Sun, Hsu, and Hwang (2009) conducted a survey method for obtaining data from the manufacturing companies in Taiwan. In addition, Wagner and Bode (2006) made use of the cross-sectional survey for collecting data from top-level executives in logistics and supply chain management positions in Germany. However, because of the need for an in-depth understanding of the supply chain risk phenomenon from the points of view of the participants in their particular social and institutional work settings, the multiple case research methodology is found suitable for this study**.** This qualitative research method helped in examining the overall picture of the causes, impacts of supply chain risks and the risk management methods among manufacturing firms in Nigeria.

Instrument Design

The research instrument used in this study is an interview guide. The interview guide consists of standardized and pre-arranged open-ended questions that help in data gathering from different respondents (Kotzab, 2005). A brief introduction on the aim of the research and the definition of the key subject "supply chain risk'' was given in the guide. This was to ensure that the respondents have the good understanding of the phenomenon under consideration. All the questions in the interview guide were coined from extant studies (Craighead et.al, 2007; Elkins, Handfield, Blackhurst & Craighead, 2009) but rephrased in order to ensure that the uniqueness of the study under consideration is ascertained based on the recommendations from academic and management experts. This prior consultation with academics and managers in the area of supply chain management helped in refining the interview guide to suit the context investigated.

The interview guide in all contains three questions which are divided into three segments. One of the segments is related to identifying the causes and impacts of supply chain risk. The second segment was related to the identification of the mitigation strategies for managing supply chain risks. The third segment is focused on the personal details of the respondents.

Sample, data collection and validation

The manufacturing firms chosen are publicly quoted. The publicly quoted manufacturing firms are chosen because they are regulated by the Security and Exchange Commission (SEC) in Nigeria. This regulatory body requires the firms to observe certain procedures and as such, they are highly monitored. This tends to increase the quality of data obtained for the study. There are 3 different manufacturing subsectors among the publicly quoted firms sampled which are Conglomerates, Pharmaceutical & Health and Food & Beverage. A total of ten manufacturing firms were analysed in all which is adequate to give a detailed understanding of the supply chain risk phenomenon. Moreover, qualitative researches emphasize the detailed and in-depth study of small samples because relevance is given priority above representativeness. (Flyvbjerg, 2006).

Most of the firms are major players in their respective sub-sectors. The approximate size of the firms (using employees' size) ranges from 200 to 4000 in number (Table 1). The respondents' designations cut across four major positions which are operations, logistics, supply chain and purchasing departments. This is the case because of the absence of distinct department called supply chain department or properly defined job titles in some of the firms. The years of experience of the respondents in their respective positions ranges from at least 10 months to 10 years.

Table 1. Characteristics of the manufacturing firms and respondents

FIRMS	RESPONDENT'S DESIGNATION	NUMBER OF YEARS IN POSITION	SUB-SECTOR	APPROXIMATE SIZE OF COMPANY (EMPLOYEES SIZE)	OWNERSHIP STRUCTURE OF COMPANY
A	Purchasing Manager	7 years	Food & Beverage	>1000	Joint venture but mainly locally owned
B	Supply chain manager	4 years	Food & Beverage	200	Joint venture
C	Head logistics	7 years	Food & Beverage	1200	Joint venture
D	Head of operations	5 years	Pharmaceutical & Health	465	Joint venture
E	Logistics manager	8 years	Pharmaceutical & Health	500	Joint venture
F	Purchasing manager	3 years	Pharmaceutical & Health	263	Wholly local
G	Logistics manager	10 months	Conglomerate	>1000	Joint venture
H	Supply chain manager	3 years	Conglomerate	>3000	Joint venture but mainly locally owned
I	Supply chain manager	8 years	Conglomerate	1200	Joint venture (51% foreign,49% local)
J	Purchasing manager	10 years	Food & Beverage	4000	Joint venture (70% foreign,30% local)

The manufacturing firms are given pseudonyms in order to maintain their anonymity. The firms are named in alphabetical order based on their real names. They are also named using alphabets from A to J. At least one firm was chosen from the sub-sectors under consideration. One of the criteria used for choosing the firms is based on the years of operation. Manufacturing firms with long years of existence, that is, at least a decade are the ones selected. Such firms tend to have well-established supply chain process and have a good understanding of the phenomenon under consideration based on experience. Another criterion used in choosing the firms is based on the firms' focus on Fast Moving Consumer Goods (FMCGs). FMCGs are products with an expected high rate of turnover, therefore firms that produce such goods are expected to have well-established supply chain process from suppliers through to end consumers (Ghosh, 2015). In addition, FMCG supply chain is an amalgam of intertwined parties such as suppliers, manufacturers, logistics service providers, warehouses, distributors, wholesalers, retailers and consumers.

An important means of validating the data, that is, ensuring credibility in a qualitative research is through the use of a suitable sampling technique (Long & Johnson, 2000). The study was conducted through ten supply chain managers or equivalents from the manufacturing firms selected. This sample size of respondents is credible as respondents are chosen based on purposive sampling technique which allows for concise information to be obtained which translates to quality data, hence, the credibility of this study (Jette, Grover & Keck, 2003; Jüttner, Peck, & Christopher, 2003; Taps & Steger-Jensen 2007; Morse, 2000). In agreement with the aforementioned, eight or fewer informants provide theoretical saturation in a qualitative study (Strauss & Corbin, 1998).

The interviews began with some sets of open-ended questions from the interview guide. Respondents were probed and encouraged to provide detailed explanations and clarifications where necessary (Harris & Brown, 2010). The idea at the outset was to tape the interview sessions but because of the firms' refusal of the audio recording method, the text documenting method was resorted to. Most of the respondents explained that the interview questions were strategic. Due to this consistent claim, the respondents were assured of using the data for research purpose only, the confidentiality of their personal details and that of their firms in order to ensure trust. This made the respondents more comfortable with the research and thus, helped in getting better responses from them. An average interview session lasted for about 2.5 hours.

RESEARCH ANALYSIS AND DISCUSSION

For the research analysis, the manual method is used for coding and analyzing the data collected through the interviews conducted. The use of the manual method is justified since the researcher is responsible for choosing the codes, themes and concepts based on the available data from outset (Bernard, 2013). This is necessary since the researcher is familiar with the data and is responsible for selecting the appropriate codes. Hence, personal involvement of the researcher is key to ensuring good analysis at the different phases from data collection through to analysis (Ghuari & Grønhaug, 2005; Kotzab, Seuring, & Müller & Reiner, 2005).

Four basic stages are followed in this study. Stage one involves transcribing of the semi-structured interview by summarizing the transcripts. In stage two, texts were coded by breaking down, examining, comparing, conceptualizing of data that yielded concepts that were further categorised. In stage three, three themes were established for each category of data collated by linking similar concepts after comparison. The final stage is composed of linking themes with some important quotations from respondents that were selected to support points for presentation in clear, coherent and concise manner (Eisenhardt & Graebner, 2007; Eisenhardt, 1991). In this study, the coding process is based on the themes established (Irvine, Warber, Devine-Wright, & Gaston, 2013). There are three established themes from the work which are particularly related to the important concepts in this research work which are: first, the causes of supply chain risk; second, mitigating strategies for managing supply chain risks and third, impacts of supply chain risks.

Thematic Analysis and Findings

In this study, quasi-statistics as a content analysis technique is used (Hsieh & Shannon, 2005). The quantitative content analysis approach involves analyzing texts in quantifiable forms and this method has been used in several studies (Cho & Lee, 2014; Harwood & Garry, 2003; Krippendorf, 2013; Lock & Seele, 2016; Priest, Roberts & Woods, 2002). This

method of analyzing qualitative research involves examining the frequency of repetition of concepts or terms from the different responses of the respondents (Becker, 1970; Holder-Webb, Cohen, Nath & Wood, 2009; Wu, 2008). Word counts as a quasi-statistics and a summative content analysis technique bring out the number of times of occurrence of ideas and their patterns in field notes and responses to open-ended questions (Denzin, 2005; Hsieh & Shannon, 2005). In this study, "word count'' is used to analyse the responses under the three major themes.

Theme 1: Causes of Supply Chain Risks

A proactive investigation and examination of potential supply chain risks in an environment is a justifiable step towards their effective supply chain risk management. This is based on the logical perspective that there is no need waiting for occurrences of disastrous events before preventive mechanisms can be put in place. Hence, using the information obtained from the interviews conducted in the ten manufacturing firms, there are a number of supply chain risks that are predominant in the developing country context investigated, which are; variation in raw material prices and quantities, transportation delays such as port delays, unexpected changes in customer demand, constant power outage and related variation in fuel price and quantity, poor communication and poor visibility of the supply chain, quality issues, accidents, political instability, seasonality of inputs, devaluation of currencies that negatively affects the price and schedule of imported raw materials, natural disasters, strikes and major global economic disruptions such as recession.

Table 2. Manufacturing Firms Responses to Causes of Supply Chain Risk

Supply Chain risks	SUB-SECTORS			
	Pharmaceutical & Health (%)	Conglomerate (%)	Food & Beverage	Total in Agreement (%)
a .supplier capacity not meeting demand	20	20	0	40
b. variation in raw material prices and quantities	30	10	20	60
c. unexpected changes in customer demand	20	20	10	50
d. incessant power outage	15	15	40	70
e. variation in fuel price and quantity	0	0	30	30
f. terrorist attack	0	10	0	10
g. strikes	0	0	10	10
h. devaluation of currencies	20	0	0	20
i. transportation delays	15	15	40	70
j. accidents	0	0	10	10
k. natural disasters	10	0	0	10
l. poor communication	10	0	10	20

m. theft	0	0	0	0
n. quality issues	10	20	10	40
o.major global economic disruptions	10	0	10	20
p .political instability	20	0	20	40
q. fire	0	0	0	*0*
r. seasonality of inputs	10	0	0	*10*
s. hoarding of inputs	0	0	0	*0*

Based on the frequency of occurrence, among the causes of supply chain risks identified, transportation delays, constant power outages, variation in raw material prices and quantities, and unexpected changes in customer's demand have the leading counts of 70%, 70%, 60% and 50% respectively based on the informants' responses. These are followed by supplier's capacity not meeting demand and political instability based on the manufacturing firms analysed (Table 2). Some of the key respondents asserted the following: respondent A from firm A explained that "transportation delays are caused by bad roads and poor road networks and that raw materials are delayed because of transportation issues". Respondent C from firm C also puts forward that "poor power supply leads to increase in the use of diesel for generating sets coupled with exorbitant bills from the institution in charge of public electricity supply in Nigeria". Respondent F from company F stated that "transportation of raw materials from Lagos port takes a whole day because of bad roads and poor road networks." Respondent G from firm G said that "we experience a sudden surge in demand and incorrect information about orders leading to stock-outs" Respondent J from firm J mentioned that "seasonal availability of raw materials and frequent changes in prices are disruptive to production as a manufacturing firm."

This exposition also revealed that transportation delays and incessant power outages (Table 2) are the major causes of supply chain risks among the Nigerian manufacturing firms considered followed by variations in raw material prices and quantities and unexpected changes in customers' demand. Terrorist attack, strikes, accidents and the seasonality of inputs are the least causes of supply chain risk respectively. Some of the specific kinds of transportation delays accounted for involve shipment delays due to trans-shipment, poor road network nationwide, unnecessary delays at the port such as port clearance delay, long distances of sources of raw materials among others. The type of transportation delays with the highest prominence among the listed are the port delays according to the respondents. Inadequate power generation and vandalism are some of the factors responsible for the poor power supply in the country. Some of the respondents opined the following: respondent B from firm B stated that "port delays caused by poor documentation and bureaucracy result in demurrage, delayed production and disgruntled customers". Also, respondent G from firm G explained that "transportation delays and constant poor power supply are the major factors that affect production in the firm"

Theme 2: Impacts of supply chain risks

The attention to impacts of risks on performance is gaining prominence among academics and professionals (Hanna & Skipper, 2009: Hendrick & Singhal, 2003; Hendrick & Singhal, 2008; Hendrick, Singhal, & Zhang, 2009). This serves as a motivating factor towards employing prompt responses to supply chain risks by making use of effective supply chain risk management strategies. Based on the interviews conducted in this study, the impacts of supply chain risks in Nigeria are:production delays, inability to meet customer's demand, forfeited opportunities in markets, negative stock market responses and reduction in shares value, increased production costs, stock out, quality compromised goods, and vulnerability/exposure of the supply chain.

Table 3. Manufacturing Firms Responses to Impacts of Supply Chain Risk

Impacts of Supply Chain Risks	SUB-SECTORS			Total in agreement (%)
	Pharmaceutical & Health (%) (%)	Conglomerate (%)	Food & Beverage (%)	
a. production delays	15	25	50	90
b. corporate and network wide risk exposure	10	0	0	10
c. reduction in shares value	20	0	10	30
d. influx production of quality compromised goods	20	30	20	70
e. increase in costs	20	20	20	60
f. inability to meet customer's demands	35	30	35	100
g. stock outs	30	20	10	60
h. ineffective decisions	0	0	0	0
i. forfeited market opportunities to competition	20	35	35	90

Using the word counts method, the impacts of supply chain risks in the Nigerian manufacturing firms based on the study at hand revealed that production delays, influx of quality compromised goods, inability to meet customer's demand and forfeited opportunities in the market to competition with 90%, 70%, 100% and 90% frequency in percentages are the major impacts of supply chain risks respectively (Table 3). Quality compromised goods are goods that do not meet the stipulated quality standards.

The impacts of supply chain risks with the least counts are entire supply chain risk exposure, negative stock market responses and the reduction in shares value. The problem of unavailability of raw materials for production will result in production delay and inability to meet customers demands as at when due. This results in the loss of market share to counterfeit products because of porous borders. Some respondents put forward the following views: respondent F from firm F explained that "power issues increase their production costs since the firm relies on generators most of the time as an alternative source of power". Respondent I from firm I stated that " constant fluctuating and low voltage of power damaged the expensive, major production machinery that was imported from Germany causing outright production delay and inability to meet orders". In addition, respondent E opined that " the use of an independent source of power by the firm for an average of 8-10 hours a day adds to the overhead costs"

Theme 3: Mitigation strategies for managing supply chain risks

Mitigation strategies help firms to reduce costs, improve customer satisfaction and ensure sustainable manufacturing operations (Tang, 2006). Based on the face to face interview conducted with respondents, the mitigation strategies for managing supply chain risks in manufacturing firms in Nigeria are:the use of control systems, multiple sourcing strategy, the use of strategic stocks, flexible transportation, monitoring trends, outsourced manufacturing, collaborative planning with supply chain partners, supply chain redesigning, secured communication links, increasing transportation viability,choice of safe locations, enhanced visibility and communications, and the use of multiple facilities.

Table 4. Manufacturing Firms Responses to Mitigation Strategies for Managing Supply Chain Risks

Mitigation Strategies	SUB-SECTORS			Total in agreement (%)
	Pharmaceutical & Health (%)	Conglomerate (%)	Food & Beverage (%)	
a. control systems	20	10	20	50
b. supply chain redesign	10	10	20	40
c. awareness, prevention, remediation and knowledge management	20	0	20	40
d. Multiple sourcing strategy	30	35	35	100
e. postponement	0	0	0	0
f. strategic stock	20	20	30	70
g.flexible transportation	20	0	40	60
h. silent product rollover	0	0	0	0
i.safe locations	10	0	0	10
j.secured communication links	10	0	10	20
k. enhanced visibility and coordination	10	0	10	20
l.increase transportation viability	10	10	20	40
m.monitoring trends	15	15	40	70
n.multiple facilities	0	0	10	10
o.outsourced manufacturing	15	30	20	*65*
p.influence customers' choices	0	0	0	*0*
q.product variety	0	0	0	*0*
r. collaborative planning	0	20	20	*40*

Using the quasi-statistics, among the mitigating strategies employed in the Nigerian manufacturing firms, both multiple sourcing strategy and outsourced manufacturing are most prominent with 100% and 75% counts in agreement with these strategies respectively. These are followed by the use of strategic stock, monitoring of trends and flexible transportation respectively (Table 4). On the other hand, the use of postponement, silent products rollover, influencing customers' choices and product variety strategies are the least adopted strategies among the Nigerian manufacturing firms. The prevalence in the use of multiple sourcing strategy among the manufacturing firms is because of unavailability of locally sourced raw materials. Outsourced manufacturing is also becoming common as a risk management strategy to reduce the negative impacts of constant power outage and transportation issues associated with inbound logistics. Some of the respondents stated the following: respondent D from firm D explained that " as a firm, they encourage the use of many suppliers because they do not want to depend on only one supplier in order to prevent stock out and raw materials are rationed among the suppliers based on availability" Also, respondent E from firm E mentioned that "they outsource production to a Chinese firm and

import the finished products back in the country because it was realized that it is cheaper for to manage instead of experiencing incessant power outages and poor local supplies of raw materials locally". Respondent G from firm G explained that "in their firm, they hold up to 1-3months stocks of raw materials in the warehouse on a constant basis to ensure continuous production".

SUMMARY OF FINDINGS AND CONCLUSIONS

In this qualitative study, the causes of the supply chain risks have been enumerated based on the sampled manufacturing firms in Nigeria. In addition, the impacts of the supply chain risks and the mitigating strategies used to manage these risks have been investigated. In concluding the study, the findings from the work are summarized in order to indicate the areas of contribution to existing literature, limitations, practical implications and finally, the areas for further research are stated.

Summary of Findings and Contributions

This research study has investigated the causes, impacts and the strategies adopted to manage supply chain risks from a developing country context especially in Nigeria. The need for this study arose from the fact that most of the studies addressing supply chain risks are concentrated on the developed countries' contexts (Bode & Wagner, 2006; Bode & Wagner, 2008; Oke & Gopalakrishnan, 2009). This study is carried out in order to fill this gap by concentrating on a developing country, that is, Nigeria. Therefore, this study investigated and enumerated the main causes of supply chain risks, their impacts and the mitigation strategies for managing supply chain risks.

From extant literatures, causes of supply chain risks are vast ranging from man-made, natural, firm internally generated and externally generated risks such as supplier capacity not meeting demand, unexpected changes in customer demand, terrorist attack, strikes and natural disasters and excess machine downtime (Blackhurst et al., 2005; Kleindorfer & Saad, 2005; Tang, 2006; Stecke & Kumar, 2009; Worthington et al., 2009).

Consequently, in a bid to contribute to extant literature and the need to focus study on the developing countries in the area of supply chain risk, an in-depth qualitative study of ten manufacturing firms in Nigeria produced the following findings; that the causes of supply chain risks common to the Nigerian manufacturing firms are not different from those experienced in developed countries except for transportation delays emanating from port delays, bad roads, poor road networks and poor power supply. Among the supply chain risks in this developing country context, transportation delays, variations in raw material prices and quantities, constant power outage and unexpected changes in customers' demand are the major causes of supply chain risks among manufacturing firms. In comparison with the extant literature from developed countries contexts, transportation delays and incessant power outage are the peculiar causes of supply chain risks in this developing context.

The impacts of supply chain risks from developing countries' contexts are in congruence with those from the Nigerian manufacturing context such as the inability to match the demand of the market to that supplied by a manufacturing firm, stockouts and quality issues (Benyoucef & Forzley, 2007; Hendricks & Singhal, 2008; Porterfield et al., 2012; Tang, 2006). However, our findings showed a certain deviation from the developing countries' context which is the influx of quality compromised goods or counterfeit brands as the unique impact of supply chain disruptions because of the country's porous borders. Furthermore, the influx of quality compromised goods, production delay and inability to meet customer's demands are the major negative effects of supply chain risks in Nigeria.

An exhaustive research on mitigation strategies revealed that the mitigation strategies employed to manage supply chain risks from extant literature and mostly from the developed contexts are similar to those used in the developing country investigated such as multiple sourcing strategy, safety stock, postponement and strategic stock (Choi & Liker,1995; Craighead et al., 2007; Lee & Billington, 1993; Lee & Christopher, 2004; Stecke & Kumar, 2009; Tang, 2006). However, among the mitigation strategies, the most popular mitigation strategies employed in the Nigerian manufacturing firms, include; multiple sourcing strategy and outsourced manufacturing whereas the least employed strategies are postponement, silent products rollover and influencing customers' choices. In comparison to the developed contexts, outsourced manufacturing is now trending in the manufacturing sector

because of the prevalent issues of transportation delays, constant power outages and the associated costs. Interestingly, the use of multiple sourcing strategy and outsourced manufacturing is common to all the manufacturing sub-sectors selected.

It has been confirmed in extant researches that the occurrence of supply chain risks is inevitable (Hanna & Skipper, 2009). Thus, this study has created more insights and awareness for incumbent manufacturing firms to know the causes of supply chain risks, the possible impacts and the mitigating strategies that can be used in managing the supply chain risks in Nigeria. On the other hand, it has also created an eye-opening information for potential entrants into manufacturing businesses to be aware of the possible supply chain risks that are prevalent among manufacturing firms in Nigeria. Therefore, this study will help manufacturing firms to be proactive in combating supply chain risks in Nigeria.

In general, this study contributes to the literature by concentrating on a developing country context and by examining the phenomenon 'supply chain risk' in the following ways: First, this study elaborates the causes of supply chain risk, the impacts of supply chain risks and the mitigating strategies in the Nigerian manufacturing firms. Second, this study shows some similarities between the developing and developed countries' contexts on the causes of supply chain risks, their impacts and the mitigating strategies for managing risks. Third, some peculiar causes and impacts of supply chain risks are highlighted in the study. To elaborate further, the occurrence of transportation delays are prominent in Nigeria because of excessive focus on road transportation, bad roads and associated inadequate road networks. Also, the problem of incessant power outages is common. Hence, these two factors contribute to the increased trend in the use of outsourced manufacturing as a mitigation strategy among the manufacturing firms. Since outsourced manufacturing allows firms to contract production to other firms who have expertise in managing the supply chain issues efficiently locally or in a geographical location where the supply chain risks are not existing. This is because the high cost of truck maintenance due to bad roads and independent power supply will increase the overhead costs of production. In addition, the influx of quality compromised goods that are imported or find their way in through the porous borders or those internally produced from poor quality raw materials in the country is a unique impact of supply chain risks in Nigeria. It was also confirmed that the mitigation strategies used by manufacturing firms considered in this study to manage supply chain risks are adopted from the developed countries. This confirms the assertion by Bruun and Meffford (1996) that developing countries do not create strategies but mostly adopt and conform strategies used in developed countries to their environments.

In this study, we had certain limitations common to other research studies. First, the number of manufacturing firms interviewed was just ten. This is a small number compared to the number of manufacturing firms in Nigeria. On the other hand, the number is justified in that a qualitative study is about an in-depth study of a phenomenon (in this case, supply chain risk). Second, only one respondent was interviewed per manufacturing firm. This is sufficient in so much that the purposive sampling technique is used in this study. This is because the best informants that are knowledgeable with the valid assessment of the supply chain risk phenomenon are the supply chain managers or their equivalent managers in this regard (Jüttner, Peck & Christopher, 2003; Jette, Grover & Keck, 2003). Third, all the manufacturing companies selected are situated in Lagos State, Nigeria. This is justifiable because most of the vibrant manufacturing firms in Nigeria have their Head Offices in Lagos because of its commercial inclination. Therefore, the manufacturing firms in Lagos are good representatives of the firms in Nigeria. Fourth, the data collection via interview mode was the only method used beacause archival data on the phenomenon investigated were not available. Also, the generalizability of this study is limited since the developing country context investigated is only Nigeria.

Finally, this study puts forward possible areas for further research. First, this qualitative study could be analysed by using other quantitative techniques. Similar studies could also be carried out in other developing countries' contexts for the basis of comparison. Second, the unique supply chain risks to the manufacturing sub-sectors could be analysed. Third, it could be interesting to find out which industry is more prone to supply chain risks. Fourth, the effects of the mitigating strategies could be quantified in terms of the benefits and costs. Also, the fit of the mitigation strategies to specific supply chain disruptions could be analysed in this context.

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ARTICLES

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DO ANALYTICALLY-ORIENTED SUPPLY CHAINS BETTER MANAGE RISKS?

ABSTRACT

Risk management has emerged as a field of operations management research due to the greater exposure of organizations to internal and external risks, as a result of globalization, outsourcing, reduction in the number of suppliers, and the need to improve cost and inventory management. Although this subject has received attention in recent years, the relationship between analytical orientation and supply chain risk management is little explored. Thus, this research verifies the impact of analytical orientation over supply chain risk management. A questionnaire was applied with micro, small and medium-sized firms of Brazilian Southeast region, obtaining 111 responses. The structural equation modeling was used for analysis and the main conclusions indicate that analytical orientation has a strong and significant impact over supply chain risk management. In this sense, those supply chains that are more analytical manage their risks better, resulting in lower perception of uncertainty.

KEYWORDS | Supply chain risk management, analytical supply chains, analytical orientation, uncertainty, structural equation modeling.

Murilo Zamboni Alvarenga
murilozamboni@hotmail.com

Marcos Paulo Valadares de Oliveira
marcos.p.oliveira@ufes.br

Hélio Zanquetto Filho
zanquetto@gmail.com

Washington Romão dos Santos
washington_romao@hotmail.com

Universidade Federal do Espírito Santo, Vitória, ES, Brazil

INTRODUCTION

In today's turbulent and uncertain environment, every company in the supply chain is susceptible to an endless number of events that can disrupt or interrupt its operations (Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scavarda, Ceryno, Pires, & Klingebiel, 2015; Sheffi & Rice Jr., 2005; Skipper & Hanna, 2009). Knowing that these events affect performance and can be devastating to the members of the chains (Blackhurst, Craighead, Elkins, & Handfield, 2005; Chen, 2018), the discussion about risk management in supply chains has grown globally both in the academic and professional arena for its potential to protect companies and chains from the negative effects of internal and external risks (Aqlan & Lam, 2015; Fahimnia, Tang, Davarzani, & Sarkis, 2015; Fan & Stevenson, 2018; Jüttner, Peck, & Christopher, 2003; Mohammaddust, Rezapour, Farahani, Mofidfar, & Hill, 2017).

Although the literature explores several factors as drivers of risk management efficiency, such as visibility, collaboration and flexibility (Kilubi & Haasis, 2015; Lavastre, Gunasekaran, & Spalanzani, 2012; Li, Fan, Lee, & Cheng, 2015; Nooraie & Parast, 2015; Tang, Matsukawa, & Nakashima, 2012; Tang & Musa, 2011; Thun & Hoenig, 2011; Wiengarten, Humphreys, Gimenez, & McIvor, 2016; Zhao, Huo, Sun, & Zhao, 2013), the impact of the chains' ability to collect, analyze and transform data into useful knowledge, in order to make decisions based on facts and data, that is, to be analytically oriented, is a point not yet explored in the literature when it comes to the use of this analytical capabilities to optimize risk management results.

The analytical approach involves the use of fact-based management to guide management decisions and actions (Ladeira et al., 2016). In this sense, being analytical allows companies to maximize decision-making processes by developing the organization's analysis and response capacity, providing better results, and generating value and efficiency in decision-making (Davenport, 2006; Davenport, Harris, De Long, & Jacobson, 2001; Laursen & Thorlund, 2010).

Therefore, analytical chains are those that provide members with useful information, compiled from the immensity of data collected, which facilitates decision-making (Sahay & Ranjan, 2008). In this sense, it is understood that if the chain is analytically oriented, it will be more efficient in identifying, evaluating, and devising strategies to mitigate and control risks, avoiding the negative impact of unwanted events.

Thus, the present research has one main objective: verify the impact of supply chains analytical orientation on supply chain risk management (SCRM). The following aspects are also explored: a) the uncertainty perception according to both, analytical orientation and risk management levels; b) the levels of analytical orientantion and supply chain risk management considering firms size.

By proposing and testing a model to verify the existence of a relationship between these two important and emerging topics in the current literature, the research aims at presenting elements that will allow organizations to increase the efficiency of their risk management efforts, avoiding the negative effects that disruptive and disturbing events may entail. Moreover, we propose that chains with higher levels of analytical orientation and better risk management process tend to perceive less uncertainty in relations amongst their members. We also aimed at contributing with scales used to measure these two emerging constructs in the literature.

After this brief introduction, the theoretical framework will be presented, conducting a discussion on risk management, followed by an approach involving analytical orientation in supply chains. In the sequence, a conceptual model will be proposed to verify the constructs' relations. Finally, reflections about the model, data analysis and conclusion, as well as research limitations and suggestions for future studies are presented.

LITERATURE REVIEW

The theoretical framework will address the issues of supply chain risk management, analytical supply chains, uncertainty and the construction of research hypotheses.

Supply chain risk management

Organizations have realized the need to manage risks in order to mitigate and prevent them for some time. Despite its relevance, management of supply chain risks is still an unexplored issue in the Brazilian scenario and relatively new on the world stage (Tomas & Alcantara, 2013; Oliveira, Espindola, & Marins, 2017, Fan & Stevenson, 2018).

Supply Chain Risk Management (SCRM) consists of identifying, assessing and controlling internal and external risks that may affect chain performance to eliminate or reduce the likelihood or impact of events that may disrupt the operations of chain members (Jüttner, Peck, & Christopher, 2003; Sodhi, Son, & Tang, 2012).

Unlike traditional risk management, focused on the organizational level alone, SCRM understands that links make organizations dependent on one another and therefore assumes a wider perspective considering the sources of vulnerabilities. Thus, it is focused on the risks associated with the chain, as well as how collaboratively chain participants can manage them (Hallikas, Karvonen, Pulkkinen, Virolainen, & Tuominen, 2004; Thun & Hoenig, 2011). In sum, management of risks in supply chains is constituted by the intersection of theories of risk management and supply chain management (Zsidisin & Ritchie, 2009).

According to Lavastre, Gunasekaran and Spalanzani (2012), SCRM is the combination of three elements: the risk attitude, the instruments used in management, and the techniques used to minimize them. The authors' study pointed out that organizations, when confronted with risks, seek to manage them along with other members of the chain. Thus, transferring the risk and managing it individually, are strategies with little acceptance by managers, considering the French companies studied.

Though being a recent issue, it can be said that there are four main stages of SCRM, typical in most of the literature, namely: (1) risk identification, (2) risk assessment, (3) risk control, 4) risk monitoring. We will define each of them below.

(1) Risk identification: Fundamental and initial phase of risk management in supply chains. The risk events can be identified on an individual company or in chain relationships. Since they may interrupt or disrupt the operations of members of the chain, it is necessary to evaluate them and propose strategies to manage them (Aqlan & Lam, 2015; Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009). It is also necessary to identify the connectivity between risks, considering that approaching them individually and developing strategies to mitigate specific risks can increase the probability and the impact of another (Chopra & Sodhi, 2004).

(2) Risk assessment: Procedure performed to classify each risk identified in step (1) on the basis of probability and impact, in order to elaborate appropriate control strategies (Aqlan & Lam, 2015; Giannakis & Papadopoulos, 2016; Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009).

(3) Control / risk management: This stage consists of developing and implementing, along with members of the chain, strategies to mitigate or prevent the occurrence of risks (Hallikas et al., 2004; Norrman & Jansson, 2004; Tummala & Schoenherr, 2011; Zsidisin & Ritchie, 2009). The commonly used strategies are: risk transfer, risk taking, risk elimination, risk reduction, and other individual analyzes of risks (Giannakis & Papadopoulos, 2016; Hallikas et al.; 2004). For Thun and Hoening (2011), risk management tools can be divided into reactive and proactive. While proactive tools are focused, most commonly, on reducing the likelihood of occurrence of unwanted events; reactive tools seek to mitigate the negative impact.

(4) Risk monitoring: It monitors SCRM progress of, adding or removing risks from the risk checklist and making new assessments, that is, taking corrective measures according to changes in the technological environment, in the chain, in the customer needs, among others, in order to verify if it is possible to reach the desired level of performance (Hallikas et al., 2004; Tummala & Schoenherr, 2011).

SCRM, if well elaborated, makes it more difficult to interrupt the organization's operations due to interruptions in the chain, and also prepares them for the occurrence of risks, making them safer and less vulnerable (Norrman & Jansson, 2004). Thus, Li et al. (2015) found that risk sharing mechanisms, as well as risk information sharing, are important for risk management in supply chains, i.e., joint efforts to manage risks, associated with the chain, result in better financial returns for organizations.

It is assumed that risk management should be managed jointly with chain members, and an efficient SCRM, as discussed in this section, is capable of identifying, assessing, mitigating and monitoring the associated risks and, therefore, will be measured as such, according to Exhibition 1 below.

Exhibition 1. Measurement Scale for Supply Chain Risk Management (SCRM)

1. Risk management in supply chains (Reflective)	
Items	**Questions**
S1	It has formal processes to identify risks.
S2	Strategies are implemented to minimize the impact of risks.
S3	Risks are often assessed by ours members.
S4	Risks are often monitored by ours members.

Analytical supply chains

Satisfactory decision making within the organizational context is not an easy task, requiring analytical skills from individuals, organizations and networks of organizations to process information, look for alternatives, and predict consequences for designing actions (Simon, 1979). In this scenario, the use of data has become as ubiquitous as the need to use analytical methods and processes to extract useful information. Therefore, it is precisely from this need that the studies on the subject emerge *Analytics*.

The terms *Business Intelligence* (BI), *Business Analytics* (BA) and *Big Data Analytics* (BDA) are often used in similar and even interchangeable contexts. Although they present common characteristics, it is possible to delineate some differences that need to be made clear to avoid confusion among the concepts. Davenport (2014) differentiates these terms from a historical perspective. BI focuses on tools to support data-driven decisions, with emphasis on extracting information and reporting. On the other hand, BA encompasses the use of statistical and mathematical skills, aligned with IT skills and business insights for decision-making. Recently, the term Big Data has become more popular because of the large amount of data, structured or unstructured, produced continuously, that can be used to discover hidden patterns, correlations, and useful information.

We define *Business Analytics* (BA) based on Laursen and Thorlund (2010), as "making the right media available for decision at the right time and for the right people", and it can be seen as an information system composed of: technological elements responsible for collecting, storing and providing information; human skills; and business processes. If all organizations can access some information through simple statistical techniques, the analytical skills go even further, because, combined with information systems; they provide more sophisticated information (Davenport, 2006).

However, as pointed out by Davenport et al. (2001), sophisticated analysis tools as well as investment in technology are not enough for organizations to transform data into knowledge, hence into value, and the human capacity to analyze, interpret, generate and act on the insights is critical to drive results from this complex process of transformation.

This thought is aligned with the arguments by Laursen and Thorlund (2010) that emphasize the importance and responsibility of decision makers to analyze the information obtained through information systems and turn them into useful knowledge to improve or develop business processes and, consequently, to generate value.

Therefore, analytical capabilities consist of a set of analytical methods and tools (Acito & Khatri, 2014), involving statistics, information technology and business knowledge that provide the opportunity to deliver large volumes of data through organization, availability, analysis and interpretation, taking into account the reality and the specifics of the business, enabling a rapid response to environmental changes (Teo, Nishant, & Koh, 2016).

Once organizations have used analytical tools such as statistical and quantitative data analysis, explanatory models, and data analysis for decision-making, business processes will be affected by changes and reorganizations, making routines more efficient and generating more value than at an earlier time (Bronzo et al., 2013). However, this requires structuring of collected data for them to be transformed into analytical knowledge, which can be fully explored and used in decision-making processes.

The study of Davenport (2006) with 32 organizations found that analytical capabilities provide organizations with mechanisms to enable them to improve pricing, identify potential customers and develop new products. Similarly, Bronzo et al. (2013) have found statistically significant results for the impact of using Analytics on financial, learning/growth, market/consumer, and organizational process capabilities.

More specifically to the present study, analytically oriented supply chains are defined as those in which their members use a set of analytical methods and tools to make better decisions regarding the flow of materials through the chain, which can be descriptive, predictive or prescriptive (Souza, 2014). Similarly, Sahay and Ranjan (2008), argue that analytical chains allow, for example, the identification of opportunities of cost reduction.

Thus, analytical supply chains use analytical methods and tools – involving statistics, information technology, and management knowledge – to turn large volumes of data into useful information to support business decisions. Through the analytical approach it is possible to map scenarios, identify the impact of expected and unexpected events, minimize inventories and streamline product flow, providing benefits to key management processes (planning, supplying, producing, delivering, returning), minimizing asymmetries (Chae, Olson, & Sheu, 2013; Chae & Olson, 2013; Davenport, 2006; Souza, 2014).

Empirically, Trkman, McCormack, Oliveira, and Bronzo (2010) verified that the use of a set of approaches and procedures for organizations to gather information, understand it and be able to apply solutions in the areas of *Supply Chain Reference Model* (SCOR) i.e., the use of the analytical approach in critical supply chain processes, results in better chain performance in addition to the findings that the relationship between analytical capabilities and performance is moderated by the organization's information systems. Still, Chae, Olson, and Sheu (2013) found the impact of analytically oriented chains on the individual performance of members and Zhu, Song, Hazen, Lee, and Cegielski (2018) explored the impact of analytics on the transparency of chains.

For the aims of this study, the analytical orientation measure in supply chains was based on Trkman et al. (2010) scale, and analytically oriented chains are considered as those in which their members efficiently process data through quantitative analysis in order to make fact-based decisions regarding chain processes. Exhibition 2 presents the proposed indicators.

Exhibition 2. Measurement scale analytical guidance in supply chains

2. Analytical orientation in supply chains. (Reflective)	
Items	**Questions**
A1	The quantitative analysis of the data directs the managerial actions.
A2	Members use the knowledge generated from the quantitative data analysis to improve the chain's processes.
A3	To support management decisions, members are able to process data efficiently.

Uncertainty

As in any day-to-day activity, as well as for each organization, innumerable are the events of risks and uncertainties inherent in supply chains. In general, the literature classifies such risk events as internal and external. External risks are related to the impacts on the environment caused by natural or human-made disasters that affect, directly or indirectly, supply chains (Fahimnia et al., 2015; Thun & Hoenig, 2011). Earthquakes, tsunamis, terrorist attacks, hurricanes, as well as political instability and economic crises are characterized as examples of this typology of risks. Internal risks, according to Aguiar, Tortato, and Gonçalves (2014) are present in the organizational environment, and these are related to the activities of the organization and the

relationships between different companies in the chain. Examples of internal risks are an oscillation in demand, information delay, available capacity, and supplier inflexibility.

Chopra and Sodhi (2004) categorized risks into: disruptions, delays, system, forecasts, intellectual property, procurement, receivables, inventory, and capacity. In all, the nine risk categories added up to 28 risk drivers, demonstrating the range of risks in the chains. Contributing to the advancement of the theme, Aguiar, Tortato, and Gonçalves (2014) developed risk constructs for supply chains composed of the following dimensions: external environment; business processes; organizational structure; management components; internal environment; comprising 51 risk factors.

For Fahimnia et al. (2015), while some risks can be prevented, others must be mitigated. It should be emphasized that internal risks are more likely to occur, while external ones have greater impacts on the chains because they are usually associated with events with severe consequences (Thun & Hoenig, 2011; Kırılmaz & Erol, 2017; Revilla & Saenz, 2017).

To measure uncertainty, this study based on the argument that in supply chains affected by environmental uncertainties, their members perceive greater degree of uncertainty in the relationships they are involved, that is, in source and delivery. Thus, to measure the uncertainty perceived by managers, the following indicators were used, as shown in Exhibition 3, below:

Exhibition 3. Uncertainty Indicators

3. Uncertainty	
Items	**Questions**
IA1	There is uncertainty about the mix of demand. (variety of products)
IA2	There is uncertainty about the volume of demand.
IA3	There is uncertainty regarding the supply of materials. (Time and volume).

Hypotheses

From the preceding arguments, it is expected that if the chain is analytically oriented, its members will be able to process information more efficiently, i.e. "... capture, integrate and analyze data and information, and use the insights generated in the context of organizational decision-making" (Cao, Duan & Li, 2015, p. 385), favoring risk management through greater prevention capacity (Ittmann, 2015).

Tang and Musa (2011) argue the need to develop a quantitative approach to manage supply chain risks, and lack of information can undermine chain decision-making. Thus, it is necessary to improve computational efficiency. In addition, it is argued by Tummala and Schoenherr (2011) that data management enables you to query, store and add risk information, assisting in the management and enhancement of SCRM.

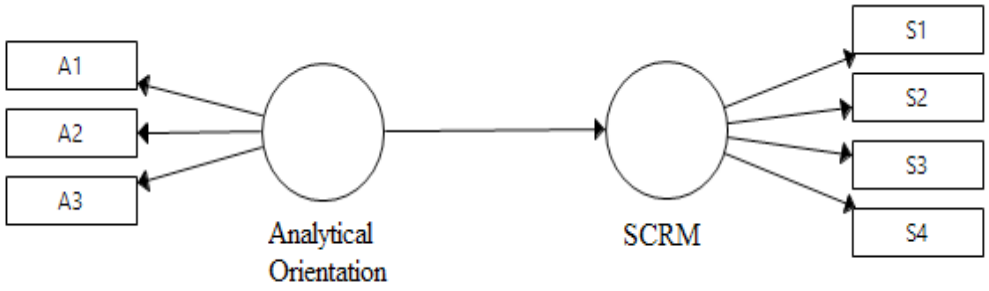
Also, the analytical orientation in supply chains is essential for the use of management tools (Ittmann, 2015), characterized as descriptive, predictive and explanatory techniques. Some examples are: "and if" (Hallikas et al., 2004; Lavastre et al., 2012; Tummala & Schoenherr, 2011); risk diagrams (Hallikas et al., 2004; Lavastre et al., 2012); cause and effect analyzes (Tummala & Schoenherr, 2011); mapping processes (Lavastre, Gunasekaran, & Spalanzani, 2012).

In this way, it is understood that in order to identify, evaluate, propose mitigation strategies and monitor risks efficiently, in addition to collaboration, flexibility, and visibility, supply chains are required to develop analytical orientation. Thus, we have the following research hypotheses:

H1: Analytical orientation positively impacts risk management in supply chains.

The research model is shown in Figure 1.

Figure1. Research Model



Based on the theoretical framework, it is understood that being analytical leads to a better understanding of the environment, reducing the perception of uncertainty. According to Galbraith (1974), the more complex and turbulent the environment, the higher the need for information processing. Likewise, identifying risks, assessing them, mitigating them and monitoring them, make the perception of uncertainty decrease, as companies feel capable of better managing environmental changes and, therefore, do not perceive them as uncertainties. Consequently, those supply chains that are more analytical or that better manage their risks reduce their uncertainty perception.

H2: Supply chains with higher level of analytical orientation have lower perception of environmental uncertainty than those with lower level of analytical orientation.

H3: Supply chains with higher level of risk management have lower perception of environmental uncertainty than those with lower level of risk management.

METHODOLOGY

Considering the purpose of the research, a questionnaire was developed to collect data referring to the constructs presented in the conceptual model. For the development of the questionnaire, a structured bibliographical review was carried out to delimit the constructs and operationalize them. In the next phase, a pre-test of the survey instrument was conducted in order to eliminate ambiguities and to validate the instrument. To do this, the questionnaire, prepared on the SurveyMonkey platform, was sent to ten professionals responsible for the production / supply chain of industries belonging to the research base, requesting them to report any doubts or issues experienced when answering to the questionnaire. Respondents considered the questionnaire quick and easy to understand, reporting no problems in answering it.

Thus, the questionnaire comprised 11 questions regarding the constructs, besides four items that made it possible to characterize the sample and served as control variables. In the questions related to the constructs, the 7-point Likert scale was used, with 1 equal to 'totally disagree' and 7 equal to 'totally agree'.

One of the difficulties of the research was to obtain a reliable database for sending the questionnaires. The best way was to use the industrial lists, which are vehicles for dissemination of companies organized through a partnership between the Industrial and Business Center of Minas Gerais and the Brazilian Editor of Special Guides (EBGE) with the federations of industries of the states involved. Considering that the registered population had 8,667 micro, small and medium-sized industries, it was decided to send to questionnaires to the whole cadastral base, given the feasibility of data collection, and considering the low costs of conducting the survey. It is worth emphasizing here that the authors of this research carried out the organization of this database to deal with problems of omissions and redundancies. Nevertheless, the difficulties to identify the population and obtain access to respondents should be mentioned, since it is not possible to guarantee that the total number of active companies in the list is correct, nor the identification of companies, because their emails could be no longer valid.

The data were collected in two stages from August to November 2017. First, an electronic contact was made with each of the registered companies in order to request the e-mail of the person responsible for the production, purchase, marketing or supply chain management of organizations. Considering that these were the subjects of the research, this proce-

dure was done to improve the quality of the questionnaire responses. This phase resulted in the return of 142 emails. In the second phase a reminder was sent for these emails with the link of the questionnaire to all the other emails registered on the databases, asking those who received the e-mail to forward it to the professionals who performed the already mentioned activities, as these were the subjects of the research. After all, 111 companies responded to the survey.

So, one of the limitations of the work is highlighted, since there is no guarantee that the available sample represents the population, due the amount of errors in the original list of companies. However, considering the descriptive statistics presented in section 3.1, a similar percentage for the three states is observed. There is also predominance of micro and small companies, reflecting the predominance in the Brazilian industry. Complementarily, approximately 83% of respondents are presidents, directors or managers, thus confirming that the survey subjects were reached. Moreover, given the hierarchical level of the respondents, good quality of responses can be expected. Thus, it is believed that this limitation did not generate significant bias in the conclusions.

The structural equations modeling was used to analyze the data. According to Hair, Black, Babin, Anderson, and Tatham (2009), the Structural Equations Modeling (SEM) provides the possibility of efficiently estimating a series of separate multiple regression equations, simultaneously calculating all of them, and using the relationships between the constructs. SEM empirically tests a set of dependency relationships through a model that operationalizes theory and provides the representation of relationships through a path diagram. The research aims at studying the relationships between constructs of analytical orientation in supply chains and the management of risks in supply chains. Therefore, the structural equations modeling and the statistical method of partial least squares (PLS) using the software SmartPLS® 3 were used.

PLS does not require large samples, does not generate identification problems and does not assume that the distribution is normal across the measurement variables (Chin, Marcolin, & Newsted, 2003). To calculate the sample size, we used the criterion of the number of arrows of a construct that points to another construct (Hair, Sarstedt, Ringle, & Gudergan, 2017). As previously reported, the database was composed of 111 cases, supporting the analysis.

Sample description

Of the 111 industries that made up the sample, 34 were located in Espírito Santo (30.63%), 38 in Minas Gerais (34.23%) and 39 in Rio de Janeiro (35.10%).

Regarding company size, micro (42.34%) and small industries (40.54%) predominated. The remaining cases of the sample comprised medium-sized industries (17.12%). As a criterion of classification, the approach of the industrial registries themselves and SEBRAE was used to classify the size of industries based on the number of employees. Thus, companies with up to 19 employees were ranked as micro, from 19 to 99 as small, from 100 to 499 as medium size. Thus, 17.12% of the participating industries were classified as medium, 40.54% as small and 42.34% as micro.

About the profile of the respondents, 15 serve as chair (13.51%), 35 are directors (31.53%), 44 are managers (39.64%), 8 are assistants (7.21%) and 9 work in positions other than those specified (8.11%). Of these, 51 have the primary function of production (45.95%), 26 of purchase (23.42%), 14 of marketing / sales (12.61%) and 20 of other functions (18.02%).

Data analysis

The first step before running the structural equation model is to analyze the measurement model. Firstly, we investigated the reflexive constructs (analytical orientation and SCRM). According to Hair et al. (Cronbach's Alpha and Compound reliability), convergent validity (AVE and loads) and discriminant validity (Fornell & Lacker's Table).

By analyzing the reliability and internal consistency of constructs, it was observed that the values obtained from Cronbach's Alpha and composite reliability guarantee the internal reliability. Furthermore, all loads obtained values greater than 0.703, and the average variance extracted (AVE) of constructs were higher than 0.70, assuring the convergent validity. In addition, discriminant validity between constructs was verified, since the square root of the AVE of constructs was proven to be greater than the correlation between them. The results of the reflective measurement model are shown in Table 1.

Table1. Results of the reflective measurement model

Latent variable	Index	Convergent validity		Reliability and internal consistency		DiscriminatingValidity
		Load	AVE	Compositere-liability	Alpha de Cronbach's	
		> 0.70	> 0.50	> 0.60 até 0.95	0.60 - 0.90	
Analytical orientation	A1	**0.773**	**0.703**	**0.876**	**0.790**	Yes
	A2	**0.877**				
	A3	**0.862**				
SCRM	S1	**0.820**	**0.749**	**0.923**	**0.888**	
	S2	**0.868**				
	S3	**0.903**				
	S4	**0.869**				

After ensuring that the measurement models are valid and reliable, the next step was to analyze the structural model by means of its predictive relevance and the relation between the constructs, being evaluated the following steps: significance and relevance of the existing relationship in the structural model, the R^2 level; predictive relevance Q^2 (Hair et. al., 2017).

The significance and relevance of the path coefficients were analyzed, verifying if they were statistically different from zero. Thus, it became necessary to perform the Bootstrapping procedure with 5,000 subsamples. Table 2 shows the results of significance and relevance tests of the path coefficients.

Table2. Significance test results

	SAMPLE MEAN	STANDARD DEVIATION	*t*	*p*
Analytical orientation -> SCRM	0.596	0.065	9.132	0.000

The results indicate that the analytical orientation construct has a positive and statistically significant impact on the management of risks in supply chains since the relationship showed a path coefficient of 0.596 and p-value of 0.000. Thus, the research hypothesis has been confirmed, indicating that supply chains where their members use quantitative data analysis to make facts-based decisions are also more efficient in managing risks.

Another measure widely used to evaluate structural models is R^2, and it is responsible for representing the effects of the combination of exogenous variables on the endogenous variable (Hair et al., 2017).

The results indicate that 35.50% of the variation in the supply chain risk management construct is derived from the variation of the analytical orientation construct. Although it can be pointed out as a medium value, it is understood to be a significant and relevant result because there are several other factors not addressed in the present study that affect SCRM. The adjusted R^2 of the model was 34.90%.

Finally, the Q^2 of the model, obtained through the blindfolding procedure with omission distance of seven was 0.245, demonstrating that the model has predictive capacity. According to Hair et al. (2017), Q^2 greater than zero represents that the exogenous

construct is, in fact, capable of predicting the endogenous construct.

Hypotheses tests

In order to form only two groups of chains (an environment with low uncertainty x high uncertainty); a cluster analysis was performed in SPSS software with the average of the uncertainty variables (IA1, IA2, and IA3). Out of all companies, 35 were classified with a low perception of uncertainty (one) and 76 with a high perception of uncertainty (two). In addition, to determine the degree of analytical orientation and the degree of risk management, the averages of the indicators of each construct were used.

From the transformations, a comparison, shown in Table 3, was drowned between the averages of the constructs for both industries with high uncertainty perception and industries with low uncertainty.

Table3. Test for difference of mean uncertainty

CONSTRUCT	UNCERTAINTY PERCEPTION	N	MEAN	STANDARD DEVIATION	STD. ERROR	WELCH TEST
Analytical orientation	Low	35	5.47	0.86	0.15	0.006
	High	76	4.90	1.21	0.14	
	Total	111	5.08	1.14	0.11	
SCRM	Low	35	5.10	1.01	0.17	0.002
	High	76	4.38	1.35	0.15	
	Total	111	4.60	1.29	0.12	

The results indicate that supply chains that perceive less uncertainty have higher average of both analytical orientation and risk management, comparing with those with high perception of uncertainty. It was also verified whetherthese two groups of chains (low perception of uncertainty x high perception of uncertainty) are statistically different regarding analytical orientation and risk management in supply chains, and Welch test was performed for equality of mean. The Welch test is used when it is not possible, through the Levine test, to verify the homogeneity of variances.

It is possible to verify that both the analytical orientation and the SCRM are statistically different across the groups. Thus, it is verified that companies that have both higher degree of analytical orientation and SCRM have lower perception of environmental uncertainty, whereas the contrary is also true. Therefore, hypotheses 2 and 3 were confirmed, corroborating the literature.

In addition, it was verified whether larger companies have both higher level of analytical orientation and better risk management. This procedure aimed at verifying if, regardless of size, industries are concerned with using quantitative data analysis in order to make better decisions involving the chain and if they understand the existence of risks associated with them and the need to manage them.

The results are presented in Table 4, as previously noted, when the size increases, the levels of analytical orientation and risk management also increase. Nevertheless, this difference was not statistically significant when conducting the tests for differences of averages.

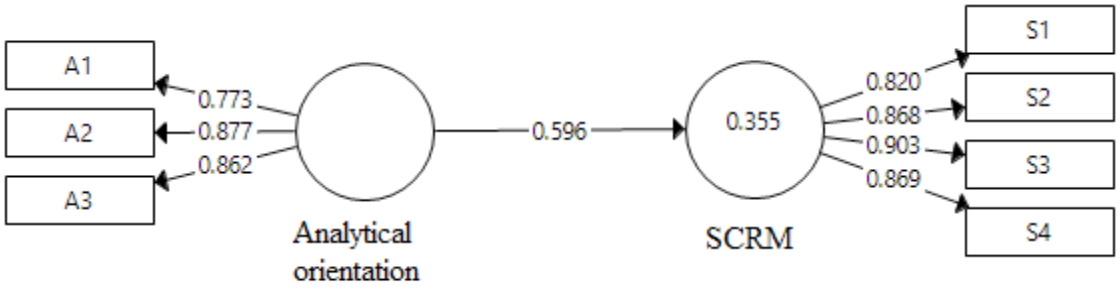
Table4. Test for medium-sized difference

CONSTRUCT	SIZE	N	MEAN	STANDARD DEVIATION	DEFAULT ERROR	LEVINE SIG.	TEST OF AVERAGE SIG.
Analytical orientation	until 19	47	4.80	1.37	0.20	0.013	Welch
	20-99	45	5.21	0.91	0.14		0.75
	100-499	19	5.44	0.82	0.19		
	Total	111	5.08	1.14	0.11		
SCRM	until 19	47	4.39	1.42	0.21	0.059	ANOVA
	20-99	45	4.59	1.22	0.18		0.68
	100-499	19	5.16	0.98	0.22		
	Total	111	4.60	1.29	0.12		

DISCUSSION AND CONTRIBUTIONS

The results obtained, presented in Figure 2, are in line with the expectations presented initially in this study and with the construction of the central research hypothesis. It was observed that the supply chain analytical orientation has a positive, significant and robust impact on SCRM. Still, it can explain 35.50% of its variation.

Figure2. Result of the structural model



As a practical implication, the results show that if supply chains want to survive from disruptions caused by the imense number of risks inherent in them – that makes impossible to produce the right quantity to the right location at the right time and in a profitable way – its members must be able to process data efficiently and, as a consequence of being analytically oriented, better manage risks. In this way, analytical approach to decision making allows supply chain members to identify possible sources of risk and to propose appropriate strategies to mitigate them, allowing them to avoid risks, maintain or recover operations in case they occur.

From a conceptual and complementary point of view, it is interesting to note that the majority of respondents hold high hierarchical positions in organizations, which may lead one to infer that they have consistent professional experience. Considering that risk management could be influenced by the manager's experience, it could be assumed that the impact identified here would be a "spurious" impact. However, considering that the experience has certain homogeneity, in the sample surveyed, the relevance of this finding is further verified, since data-based decision making was proven to improve risk management in the supply chain.

Although it is not the primary objective of this research, it was observed that there is no difference across levels of analytical orientation and risk management for micro, small and medium-sized companies, that is, regardless of size, companies are awareness about the importance of making decisions based on data and with the adoption of risk management procedures. This can be a consequence of the better training of industrial managers, micro and small companies, and can also happen due to

the broad access to technologies and computational methods nowadays.

In a complementary way, this study showed that those chains with higher degree of analytical orientation or greater degree of risk management present lower level of uncertainty perception. This result makes sense conceptually because a greater capacity to use the data for decision making, and the understanding that the uncertainty is manageable imply greater security for the members of the supply chain, that´s why the perceived risk would be smaller. In this sense, what would be considered uncertain might not be uncertain depending on the levels of analytical orientation and risk management. Therefore, it is concluded that both constructs, the analytical orientation in supply chains and the SCRM, imply less uncertainty perception in their operations because the members of the chain are more aware of their processes and the risks associated with them.

Conceptually, this article intends to contribute to the literature by relating two constructs, relevant to the management of supply chains, considering that the environment is becoming increasingly uncertain.

Limitations and future research

As main limitation, the survey was answered by only one member of the chain, who gave his opinion about the chain as a whole, where the ideal would be to obtain answers from at least one supplier, one manufacturer and one buyer belonging to the same chain. Another limitation is the low number of medium-sized companies among those that participated in the research.

For future research, we suggest verifying the role of analytical orientation in the relationship between risk management and other capabilities that affect the construct, and if analytical orientation and risk management help supply chains recover from unexpected events by improving resilience. As a suggestion, new constructs can be included to increase the explanatory power to predict supply chain risk management, such as visibility, collaboration, and flexibility.

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ANALYTICAL SUPPLY CHAINS: ARE THEY MORE RESILIENT? A MODEL'S PROPOSITION

ABSTRACT

Understanding that disruptions can be devastating, the ability of supply chains to return, as quickly as possible, to their normal state, after disruptions, has been considered as important as optimizing their flows. According to the literature, companies must develop capabilities and invest in risk management to improve their supply chain resilience, however almost nothing has been investigated about the role of the analytical orientation for those purposes. Assuming that analytical orientation is essential for supply chains to recover from interruptions, this theoretical essay aimed at proposing its inclusion in an initial supply chain resilience model, based on literature review. As a contribution, this paper aims at presenting a model that will enlarge the discussion about this theme, which can be empirically tested in a future research.

KEYWORDS | Supply chain resilience, analytical supply chains, business analytics, resilience capabilities, model.

Murilo Zamboni Alvarenga
murilozamboni@hotmail.com

Marcos Paulo Valadares de Oliveira
marcos.p.oliveira@ufes.br

Hélio Zanquetto Filho
zanquetto@gmail.com

Washington Romão dos Santos
washington_romao@hotmail.com

Universidade Federal do Espírito Santo, Vitória, ES, Brazil

INTRODUCTION

In today's turbulent and uncertain environment, characterized by huge global competition, large and complex chains, increased customer expectations, shortened product life cycles, rapid technological innovations, increased outsourcing, and demand volatility, each company in the supply chain is susceptible to an indefinite number of events that can interrupt their operations (Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scavarda, Ceryno, Pires, & Klingebiel, 2015; Sheffi & Rice Jr., 2005; Skipper & Hanna, 2009).

According to Zsidisin and Wagner (2010), interruptions in supply chains derive from events that can occur both inside and outside the supply chain's boundaries. Random events (earthquakes, illnesses, storms, hurricanes), accidental events (fires, human errors, equipment breakdown) or intentional situations (terrorism, robberies) are the main causes of supply chain disruptions (Carvalho & Machado, 2007; Sheffi & Rice Jr., 2005).

Given that such disruptions affect performance and can be devastating to supply chain members (Blackhurst, Craighead, Elkins, & Handfield, 2005), an important question, pointed out by Soni, Jain and Kumar (2014), is to identify what leads some organizations to collapse while others can thrive and grow. Thus, to become resilient, and quickly recover from disruptions, is emphasized, by both managers and academics (Brusset & Teller, 2017; Kamalahmadi & Parast, 2016)gaps in current research, and future directions on the topic. For this purpose, we employed two methods to collect publications in supply chain resilience. First, we selected keywords and searched the relevant databases and journals. Next, we tracked the references of those papers collected in the first method to look for other publications published in conference proceedings and book chapters. As a result, a sample of 100 papers was collected, studied, and analyzed. We summarize our findings in several areas including enterprise and supply chain resilience definitions, supply chain resilience principles, and supply chain resilience strategies. Based on the assessment, we develop a framework for the principles of supply chain resilience that can be used as a basis for understanding supply chain resilience. (C.

Thus, a proactive and effective method that allows supply chains to recover from expected and unexpected interruptions, is essential to build capabilities that make them more resilient, i.e. cabable to return, after disruptions, as fast as possible to their normal state or improve in order to avoid collapse of their operations and maintain profitability of their members (Christopher & Peck, 2004; Jüttner & Maklan, 2011; Pettit, Fiksel & Croxton, 2010; Ponomarov & Holcomb, 2009).

In general, resilience capabilities more often identified in literature are collaboration, flexibility, and visibility, as well as risk management procedures (Brandon-Jones, Squire, Autry, & Petersen, 2014; Christopher & Peck, 2004; Colicchia, Dallari, & Melacini, 2010; Jüttner & Maklan, 2011; Pettit, Fiksel, & Croxton, 2010; Ponomarov & Holcomb, 2009; Scholten, Scott, & Fynes, 2014; Wieland & Wallenburg, 2013)capabilities (visibility.

However, there is a gap in literature concerning the role and impact of supply chains ability to collect, analyze and transform data into useful knowledge in order to make decisions based on facts and data, that is, the impact of analytical orientation over supply chain resilience.

The analytical approach, as pointed out by Ladeira et al. (2016, p. 487), involves: "[..] the extensive use of critical data and explanatory and predictive models, as well as fact-based management to guide management decisions and actions." In this sense, being analytical allows companies to maximize decision-making processes by developing the organization's capacity to conduct analysis and act, providing better results by generating value and efficiency in decision making (Davenport, 2006; Davenport, Harris, De Long, & Jacobson, 2001; Laursen & Thorlund, 2010).

Under the supply chain perspective, being analytically oriented means being able to provide members with useful information, drawn from the vast amount of data collected, facilitating the decision-making process (Sahay & Ranjan, 2008) to overcome uncertainties (Chen, Chiang, & Storey, 2012) and to favor the recovery from interruptions. Thus, it is pertinent to consider the analytical orientation of supply chains as capability in resilience. According to Galbraith (1974), the more complex and turbulent the environment, the greater is the need for information processing.

Therefore, the present theoretical essay aimed at proposing the inclusion of analytical orientation in the preliminary model of supply chains resilience, based on literature review.

Using the taxonomy of Colquitt and Zapat-Phelan (2007), we expect to contribute to the discussion about resilience in supply chains by presenting a model that, although it has not yet been empirically tested, was conceptually grounded and validated. For this, we used the methodology known as Proknow-C (Afonso et al., 2012), where, based on 72 articles indexed on Web of Science or found on Ebsco, Science Direct and Emerald in the last 30 years with titles containing the terms "Supply Chain Resilience" or "Resilient Supply Chain". From the initial results, the most cited papers were selected (21 articles representing 90% of the citations on the topic) to identify the main antecedents of resilience in supply chains. Moreover, the most current articles, which were compatible with the theme and published in high-impact journals, were used to build the grounds of the initial model.

Thus, in line with Colquitt and Zapat-Phelan (2007), the initial model sought to capture the concepts developed by other theoretical and empirical studies, as well as to clarify and extend the conceptual approach used in previous studies, with two main contributions. The first by including a new construct in the model and the second by introducing new relationships between the model's constructs. That is, the idea is to propose an advance in the resilience knowledge and communicate with other researchers, making possible to test it empirically.

It is worth mentioning that the we intend to carry out empirical tests and publish the results in future paper. We intend to follow the taxonomy already mentioned, expanding the frontier of knowledge by building new theories based on theories available, making the cycle: conceptual advance, empirical test and new conceptual advance. Thus, expanding knowledge and presenting it in a new or different direction is possible (Colquitt & Zapat-Phelan, 2007). In order to develop an extended theoretical model, these two emerging and important themes were unified, aiming at contributing to both academics and practitioneers.

THEORETICAL DISCUSSION

In this chapter the theoretical foundations are presented involving supply chain resilience and supply chain analytics, which support the model presented in this paper.

Supply Chain Resilience

Authors such as Bhamra, Dani, and Burnard (2011) argue that the notion of resilience was grounded in ecology, related to ecosystem stability, whereas Ponomarov and Holcomb (2009) say that it has its roots in social psychology, considering the differences in behavior of individuals when facing adversity (Rutter, 2012).

However, it is known that resilience is a multidisciplinary construct that has many facets, being studied from ecological, psychological, economic and organizational perspectives. In recent years, the term resilience has gained strength in the research on supply chain management (Bhamra, Dani, & Burnard, 2011; Ponomarov & Holcomb, 2009)technological and environmental.

Christopher and Peck (2004) define resilience in supply chains as the chain's ability to return to its status quo or move to a more desirable one after suffering disruption. Ponomarov and Holcomb (2009, p. 131) argue that supply chain resilience can be conceptualized as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function".

The present study considers, from the readings and main definitions, that resilience of supply chains - SCRES - should be defined as a result, that is, the return of the chain to its natural state, or even improvement, after the occurrence of disruptive events, driven by the development of adaptive capacity and prevention. Thus, we argue that only recovery should be considered as a SCRES dimension.

This approach differs, for example, from the definition proposed by Ponomarov and Holcomb (2009) that consider the maintenance of the desired level of operations (robustness) and the preparation for events (risk management) as dimensions of resilience. Similarly, it differs from the definition proposed by Wieland and Wallenburg (2013) that is more closely associated with adaptive capacity, which we consider as being an antecedent of resilience.

Our thought goes along with Brandon-Jones et al. (2014) that consider resilience as a result provided by the development of capabilities, where maintaining operations means robustness and resilience means the return of operations. Similarly, it is observed that a deterministic disruptive event is the starting point of resilience, because only preparing for probabilistic events is related to risk management and does not determine resilience level (Jüttner & Maklan, 2011).

Christopher and Peck (2004), as well as Soni, Jain and Kumar (2014) argue that resilience can be built within the chains, that is, there are certain capabilities that, if developed, increase resilience. Sheffi and Rice (2005) present redundancy and flexibility, while Christopher and Peck (2004) develop a theoretical model involving collaboration, risk orientation/culture, agility and (re) building ability to return from disruptive events.

Research shows that in order to confront vulnerabilities, supply chains must develop capabilities, which are defined as "attributes that enable the company to anticipate or recover from disruptions" (Pettit, Fiksel, & Croxton, 2010, p. 6). It is relevant to point out that these are seen here as attributes which enable chains to recover or be prepared in order to recover from disruptions. As such, recovery would be associated to resilience and anticipation to risk management.

As previously discussed, the capabilities that most appear as determinants of SCRES are: collaboration, visibility, flexibility, speed and, in addition to these capabilities, risk management procedures (Brandon-Jones et al., 2014, Christopher & Peck, 2004, Colicchia et al., 2010, Jüttner & Maklan, 2011, Pettit et al., 2010, Ponomarov & Holcomb, 2009, Scholten et al., 2014, Wieland & Wallenburg, 2013). It is interesting to note that, according to Ponomarov and Holcomb (2009), the capabilities must be interrelated and improved together to be resilient.

It should be noted that although it is one of the capabilities that most appear as antecedents of resilience, speed appears to be a dimension of resilience, that is, the speed at which the supply chain itself manages to recover. Given that the chain's existing velocity is affected by the rupture, in addition to the absence of studies that specifically address the impact of speed on resilience, we chose not to approach it in the study as a resilience capability belonging to the resilience capability package.

Thus, it is proposed:

P1a: *Supply chain resilience is positively impacted by a resilience capabilities package*.

Collaboration

With regard to resilience in supply chains, Jüttner and Maklan (2011) have identified in an empirical multi-case study that, in a scenario of global financial crises, collaboration among members of the supply chain can function as a mechanism to contain negative impacts of disruptions.

It is also known that communication and cooperation among members of the chain impact, in a statistically significant way, the resilience of the chain as a whole (Wieland & Wallenburg, 2013). On the other hand, according to Scholten and Schilder (2015), although the existing literature points out that the collaborative relationship between supply chain members is part of the resilience, little attention has been given to how it actually exerts influence, being one of the gaps discussed in this study.

P2a: *Collaboration is a resilience capability that belongs to the resiience capability package*.

Flexibility

The importance of flexibility to adapt to environmental uncertainties is empirically verified in the study by Merschmann and Thonemann (2011), while Swafford, Ghosh, and Murthy (2008) verified the agility of chains and competitive performance of the business. On the other hand, Vickery, Calantone, and Droge (1999) did not find a statistically valid relationship between the importance attributed by the managers' perception of capabilities on flexibility and the amount of uncertainties suffered by supply chains.

According to Sheffi and Rice (2005), although redundancy, that is, having reserves of resources is an alternative to respond to disruptions, a better way is to improve the flexibility of the chain, as it results in benefits and gains in operating efficiency in normal routine.

In order to be resilient, the chain must develop a certain degree of flexibility, allowing rapid input changes or changes in the way inputs are generated, as well as outputs or the way outputs are generated, as Pettit, Fiksell and Croxton (2010) argue. These can be developed, for example, with multiple sources of supply and replenishment, contract flexibility, risk sharing, inventory management, among others.

Jüttner and Maklan (2011) found that the chain flexibility in reallocating and enhancing capacity utilization, inside or outside the network, allows costs to be managed and profits kept in situations of disruption. Scavarda et al. (2015) found, in a study of the Brazilian auto industry, that flexibility results

in resilience, however, they also found that the organizations investigated were more concerned with internal flexibility rather than flexibility in the supplier/buyer relationship.

P3a: *Flexibility is a resilience capability that belongs to the resilience capabilities package*.

Visibility

Visibility is essential to make the supply chain more resilient as it provides the ability to visualize, in complex environments, inventories and demand, enabling changes in flows when there are interruptions, and it is positively associated with agility, i.e. how quickly a supply chain would react to environmental changes (Brandon-Jones et al., 2004; Christopher & Peck, 2004).

Authors such as Jüttner and Maklan (2011) have qualitatively verified the relationship between visibility and resilience, since it makes it possible to quickly perceive the occurrence of the risk event and improve decision making. Brandon-Jones et al. (2014), therefore, were the first ones to verify this relationship quantitatively, observing a significant and positive impact. Therefore, based on these surveys, it is proposed:

P4a: *Visibility is a resilience capability that belongs to the resilience capabilities package*

Supply chain risk management

Supply chain risk management (SCRM) has a direct impact on the supply chain resilience, especially in relation to risk identification and evaluation, preventing chains from events that may disrupt their operations, as well as allowing the development of actions to recover from disruptions (Colicchia et al., 2010; Graeml & Peinado, 2014; Jüttner & Maklan, 2011; Wieland & Wallenburg, 2013).

Jüttner and Maklan (2011) argue that if risk management provides knowledge about environmental risks as well as how to mitigate their impacts, it makes the supply chain more resilient. Likewise, Graeml and Peinado (2014) found a positive impact of risk orientation over supply chain resilience, and Colicchia, Dallari, and Melacini (2010) found that adopting effective risk management strategies to deal with lead time variability, increases supply chain resilience.

P5a: *supply chain risk management has a positive impact on the supply chain resilience*.

Thus, it is observed that SCRM directly impacts the resilience of the supply chain, preparing it for the occurrence of events that may interrupt its operations, and so prevention can be considered a SCRM dimension, not a resilience dimension. At the same time, it is impacted by the capabilities package developed by the chains. This is because, for risk management to be efficient, the supply chain must adopt a collaborative management approach with its customers and suppliers, be flexible and able to receive and provide information in real time, with quality and precision, favoring visibility (Kilubi & Haasis, 2015; Lavastre, Gunasekaran, & Spalanzani, 2012; Nooraie & Mellat Parast, 2015; Tang, Matsukawa, & Nakashima, 2012; Tang & Musa, 2011; Thun & Hoenig, 2011; Wiengarten, Humphreys, Gimenez, & McIvor, 2015; Zhao, Huo, Sun, & Zhao, 2013).

P6a: *Supply chain risk management is positively impacted by the resilience capability package developed by the supply chains*.

Environmental uncertainty

Another point to be emphasized is that the need to develop capabilities is associated with the turbulence of the environment where the members of the chain are inserted. Uncertainty is related to events that can not be known with complete precision in order to develop risk mitigation strategies (Radivojevi & Gajovi, 2014). For Galbraith (1977, p. 36), uncertainty "is the difference between the amount of information *required* to perform the task and the amount of information already possessed by the organization." The greater the difference, the greater the uncertainty regarding the outcome of the decisions.

Factors such as globalization, outsourcing, supplier dependence and supply networks, consumer behavior and intensive use of technology have raised the level of environmental uncertainty, influencing the decision making and supply chain performance (Tang & Musa, 2011). Scavarda et al. (2006) and Pettit, Fiksel, and Croxton (2010) emphasize the importance of the balance between capabilities and vulnerabilities, since high levels of vulnerabilities and low capabilities result in excessive risk and, conversely, degrade profitability due to excessive investment in protection mechanisms.

Therefore, it is expected that all structural relations of the model will be moderated by the environment, since, when there is low turbulence, the proposed relationships amongst the package of capacities, supply chain risk management (SCRM) and chain resilience SCRES), tend to be smaller than those of more turbulent environments.

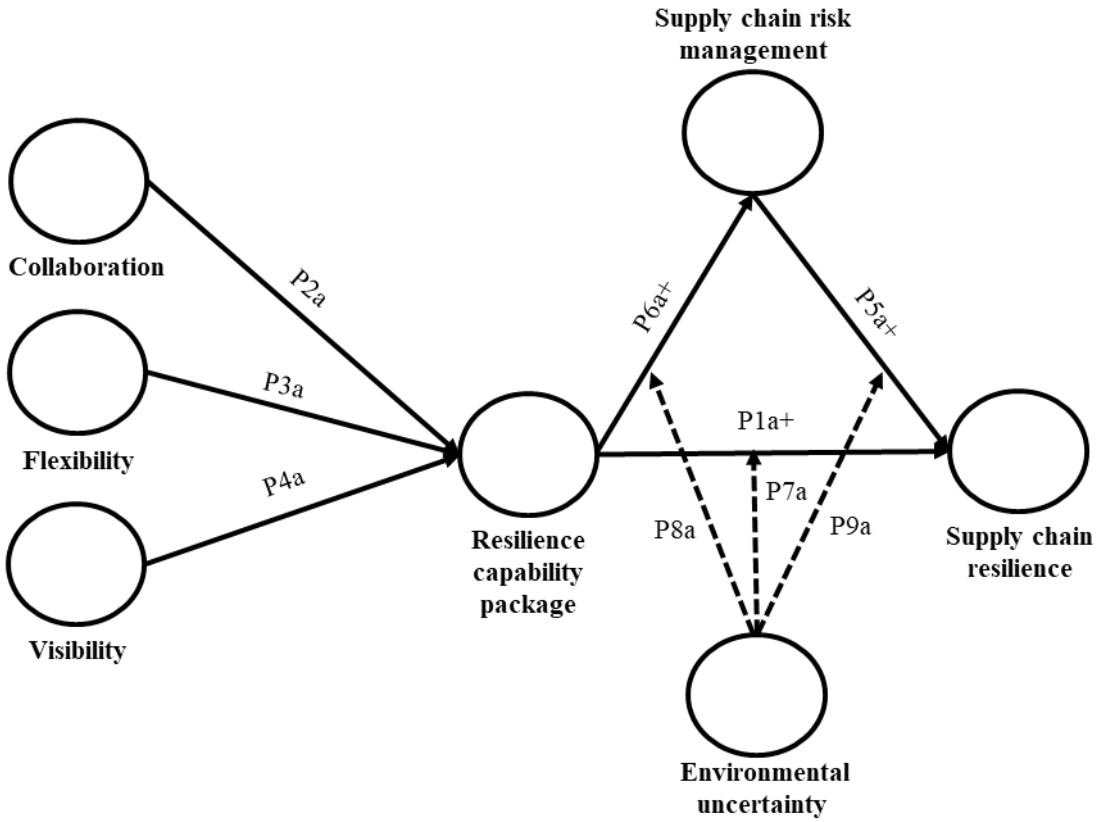
P7a: *The strength of the relationship between the capability package and the resilience of supply chains is moderated by the degree of uncertainty and dynamics of the environment*.

P8a: *The strength of the relationship between the capability package and the supply chain risk management is moderated by the degree of uncertainty and dynamics of the environment*.

P9a: *The strength of the relationship between supply chain risk management and its resilience is moderated by the degree of uncertainty and dynamics of the environment*.

Based on the literature on the subject, the resilience capability package, formed by collaboration, flexibility and visibility, is expected to positively impact the supply chain resilience. In addition, it is expected that this same package will have a positive impact on the supply chain risk management (SCRM) and, finally, on the supply chain resilience (SCRES) itself. Moreover, all relations hypothesised are moderated by the environmental uncertainty. Thus, this initial model is presented in Figure 1.

Figure 1. Proposed modern model



Source: The authors.

However, it is argued that the model initially presented is capable, but insufficient to explain the resilience of supply chains. This is because the literature ignores an essential factor to face the uncertainties and, consequently, to recover from disruptions. Thus, in view of the increasing volume of data that chain members have and may have access to, and the need to analyze them in order to make analytically grounded decisions, the insertion of analytical orientation as an additional capability in resilience will be discussed next.

Supply Chain Analytics

Simon's studies (1955, 1956, 1979) brought to the organizational research insights that broke ancient paradigms and paved the way for the emergence of new theories. If classical / economic theory considered an absolute rationality, apart from reality, in which there was the possibility of reaching an optimal decision, the author's findings showed that, in reality, man is endowed with a bounded rationality, since one does not have the time, information, or the knowledge to make an optimal decision. In this sense, any decision made by the individual will be at most satisfactory.

However, a satisfactory decision is not easy to achieve, requiring individuals, organizations and networks of organizations to have analytical skills to process information, seek alternatives, and calculate consequences for designing actions (Simon, 1979). It is precisely from this need that the studies on the Business Analytics theme emerge.

It occurs that (1) the large amount of data generated in organizations, on a daily basis, outside and inside their chains, (2) the reduction of the gap between business strategy and data management, and (3) the perception that grounded decisions are critical at each organizational level, are movements that intensify the usefulness and need of statistics to work along with information technology and business knowledge to transform data into information in order to improve decision making (Acito & Khatri, 2014). Still, the Business Analytics phenomenon is favored by the decrease in costs associated with the technological elements needed to be analytical (Acito & Khatri, 2014)

Business analytics (BA) is defined, on the basis of Laursen and Thorlund (2010), as to provide the right support for decision, at the right time and for the right people, and can be seen as an information system composed by: technological elements responsible for collecting, storing and providing information; human skills; and business processes. If some information can be used by organizations, by means of simple statistical techniques, the analytical skills go beyond of just simple statistics, since, in addition to information systems, they provide more sophisticated information (Davenport, 2006).

However, as pointed out by Davenport et al. (2001), only investments in sophisticated analysis tools and technologies are not enough for organizations to transform data into business knowledge, that is, useful knowledge that can add value to the organization. According to the authors, it is the human capability to analyze, interpret, generate and act with the insights generated through the data analysis and critical factors of this complex transformation process, using advanced technology and analysis, that is the driver of results that can add value to the business.

This approach is also in line with the arguments by Laursen and Thorlund (2010), since they emphasize the importance and responsibility of decision makers to analyze the information obtained through information systems and transform them into useful knowledge to improve or develop business processes and, consequently, generate value.

Therefore, analytical capabilities consist of a set of analytical methods, tools (Acito & Khatri, 2014) and skills, involving statistics, information technology and business knowledge that provide the opportunity to provide large volumes of data, through organization, availability, analysis and interpretation, considering the reality of the business and the specificities of the environment in which it is inserted, making it possible to develop and apply more satisfactory decisions. Importantly, visibility, previously presented as a capability in resilience, refers to the ability to visualize, in complex environments, inventories and demand. On the other hand, the analytical orientation does not refer to visualization, but to the analysis of descriptive, predictive, prescriptive, and inquisitive nature, conducted to guide and support the decision-making process.

Once organizations have used analytical tools such as statistics, explanatory models, and data analysis for decision making, business processes will be affected by changes and reorganizations, making routines more efficient and generating more value than at an earlier time (Bronzo et al., 2013). Thus, BA results in changes in the way managers see the business, allowing them to observe obsolete processes and replace them with new ones, more efficient and effective to the objectives of the organization. According to Bronzo et al. (2013), for this to occur, the data collected need to be transformed into analytical knowledge, which can be fully exploited and used in decision making.

As discussed by Teo, Nishant and Koh (2016), BA empowers identification of changes in consumer behavior, new product development opportunities,

new markets, and absorption of external information on, for example, customer perceptions about the products and services, and thus, is adaptive, innovative and absorptive, therefore, a dynamic capability.

Davenport's (2006) study of 32 organizations involved in quantitative analysis found that analytical capabilities provide organizations with mechanisms that allow them to improve pricing, identify potential customers, and develop new products. Similarly, Bronzo et al. (2013) found statistically significant results for the impact of using Analytics over the dimensions of the BSC (Balanced Scorecard).

More specifically, Souza (2014, p. 595)I describe the application of advanced analytics techniques to supply chain management. The applications are categorized in terms of descriptive, predictive, and prescriptive analytics and along the supply chain operations reference (SCOR argues that "supply chain analytics focuses on the use of information and analytical tools to make better decisions regarding material flows in the supply chain". Similarly, Sahay and Ranjan (2008) argue that analytical chains allow, for example, to identify opportunities for cost reduction.

Chae and Olson (2013) propose a framework that would represent analytical supply chains, composed by data management, process management and performance monitoring capabilities. In this way, the analytical approach, through the acquisition and transformation of data into information, qualifies supply chains, for example, to map scenarios, identify the impact of expected and unexpected events, minimize inventories and improve product flows, provide benefits to the key management processes (planning, supplying, producing, delivering, returning) and minimize asymmetries between the desired and actual performance (Chae, Olson, & Sheu, 2013; Chae & Olson, 2013; Davenport, 2006; Souza, 2014)data management resources (DMR.

Taking into account that analytical techniques can be descriptive, prescriptive and predictive, Souza (2014) summarizes them in relation to each dimension of the SCOR model, except to plan, since, according to the author, this dimension is present in all others. The summarization is presented in Table 1, below.

Exhibition 1. Analytical techniques.

	SCOR Model			
Analytics techniques	**Source**	**Make**	**Deliver**	**Return**
Descriptive	• Supply chain mapping	• Supply chain visualization		
Predictive	• Time series method (moving average, exponential smoothing, autoregressive models)			
	• Linear, non-linear and logistic regression			
	• Data-mining techniques (e.g., cluster analysis, market basket analysis)			
Prescriptive	• Analytic hierarchy process	• Mixed-integer linear programming (MILP)	• Network flow algorithms	
	• Game theory	• Non-linear Programming	• MILP	
			• Stochastic programming dynamics	

Source: Souza (2014).

Empirically, Trkman, McCormack, Oliveira, and Bronzo (2010) found that the use of the set of approaches and procedures that allow organizations to gather information, understand them and be able to apply solutions to SCOR areas of supply chain management, i.e. the analytical approach, in processes, results in better chain performance, with the relationship between analytical capabilities and performance being moderated by the organization's information systems. Still, Chae, Olson and Sheu (2013) verified the impact of the analytics in supply chains over the individual performance of their members.

Based on the above discussion, it is expected that, if a supply chain is analytically oriented, its members will be able to process information more efficiently, i.e "[...] to capture, integrate, and analyze data and information, and use the insights gained from data and information in the context of organizational decision making." (Cao, Duan & Li, 2015, p. 385), favoring resilience through prevention, adaptation and efficient decision making.

If, on the one hand, no studies were found in the literature that directly relate the constructs, on the other hand the theories presented seem to support this relationship, since the definitions of supply chain analytical orientation are extremely related to the ability to collect and analyze information and events from internal / external environment, and make satisfactory decisions that allows organizations / chains to adjust and improve processes, adapt, and consequently facilitate the recovery or improvement of the production flow and information in case of disruptions. Therefore, it can be considered as resilience capability.

Therefore, from the foregoing, it is proposed:

P1b: *The analytical orientation in supply chains is a resilience capability.*

P2b: *The insertion of analytical orientation in supply chains as resilience capability strengthens the relationship between resilience capabilities package and supply chain resilience.*

In addition, authors such as Tang and Musa (2011) argue the need to develop the quantitative approach, both academically and in a practical way, in order to manage risks in supply chains, highlighting that the lack of information may undermine decision-making within the chains. Thus, it is necessary to improve computational efficiency. Similarly, it is argued by Tummala and Schoenherr (2011) that data management allows to browse, store, and add information about risks, helping with the management and improvement of SCRM as a whole.

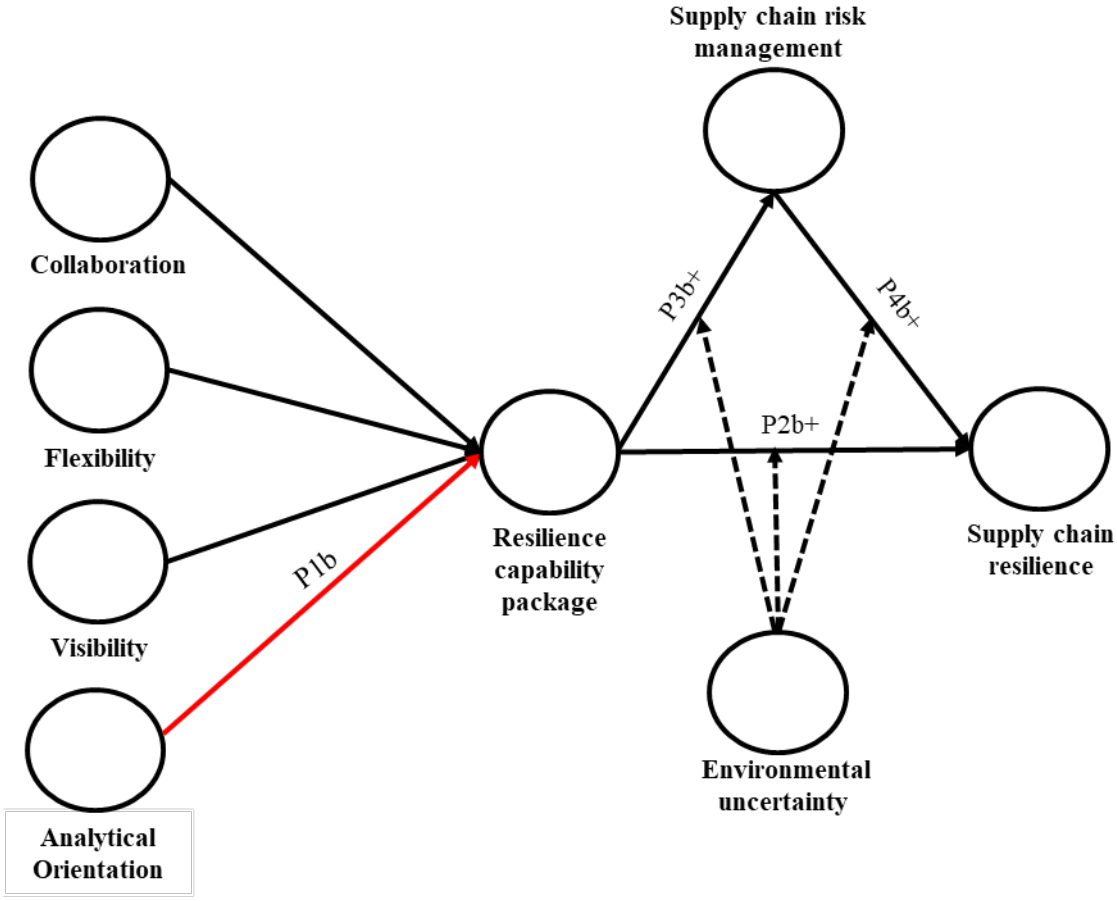
In order to identify, evaluate, propose mitigation strategies and monitor risks, supply chains need to develop the capabilities discussed in previous sections, as well as be analytically oriented in order to efficiently identify risks and transform uncertainties into risks, so that one can manage them, make better decisions and, consequently, make the supply chains more resilient. Therefore, it is proposed:

P3b: *The insertion of analytical orientation into supply chains, as a resilience capability, fortifies the relationship between the resilience capability package and SCRM.*

P4b: *Indirectly, the insertion of analytical orientation into supply chains, as a resilience capability, strengthens the relationship between SCRM and SCRES.*

Figure 2 below shows the propositions.

Figure 2. Propositions with insertion of analytical orientation



Source: The authors.

FINAL REMARKS

This theoretical essay was intended to discuss the insertion of the analytical orientation in an initial model of supply chains resilience, proposing an extended model. To justify its insertion, we discussed what is meant as resilience in supply chains, in addition to pointing out the main determinants of resilience addressed in the literature, presenting an initial model that was argued to be insufficient.

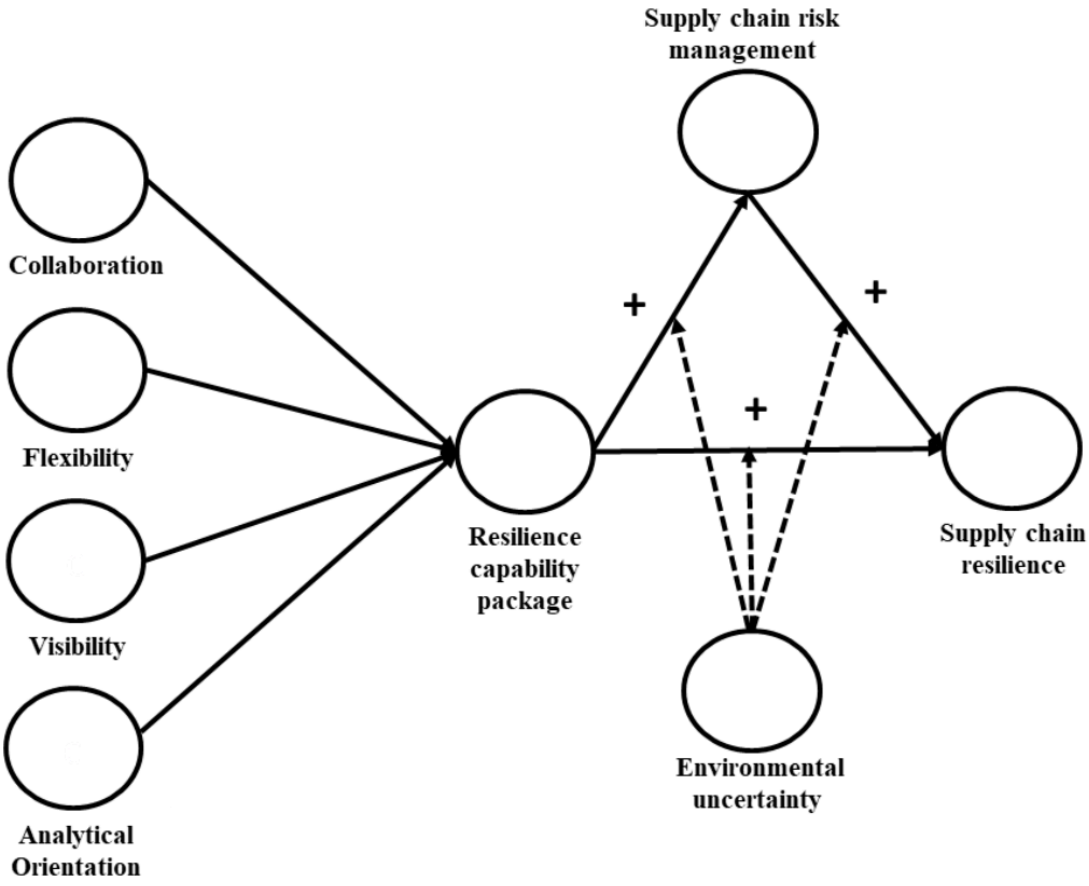
We highlight the view of resilience in supply chains adopted in this reserch. Although some previous researches assume adaptation and prevention as dimensions of resilience, in this research we assume that they both precede it. Therefore, resilience is composed by recovery and improvement dimensions. We assume the premisse that resilience can only be identified after disruptions.

In this sense, we argued that resilience in supply chains is a consequence, or a result from capabilities development. Therefore, the resilience capability package, composed by collaboration, flexibility and visibility, is capable to impact and explain resilience variance. Likewise, risk management in supply chains, identification, evaluation and control of events, which can disrupt supply chain operations, makes them more preventive and resilient. Like resilience, risk management in supply chains is expected to be impacted by the resilience capabilities package. In addition, we propose that all relationships in the structural model are moderated by the environment.

However, we found a gap in literature that ignores the role as well as the impact of analytical orientation on the recovery of disruptions. Thus, in our view, a supply chain analytically oriented is more capable to adapt and be prepared, and, consequently, to be more resilient. Therefore, it is theoretically pertinent to extend the initial model by adding analytical orientation as a component of resilience capability.

The expanded model is shown in Figure 3.

Figure 3. Expanded model proposed



Source: The authors.

The argument that grounds these propositions is that to develop resilience, intuition alone is not enough. Goals, indicators and ongoing follow-up of those involved are required to develop, structure and maintain capabilities that will make possible risk management to return to the previous stage, after disruption. Neglecting such conditionings can increase supply chain risks for participants, decreasing their reputation and their ability to reach commitments made with their customers and suppliers. Reducing uncertainties helps decision-making and allows organizations to capture the appropriate results, improving long-term partnerships and alliances. In a specific context, the socio-political environment, where the supply chain members are inserted, can increase the level of uncertainty and generate the need to improve resilience capabilities to avoid operational collapse.

The disruption of Samarco dam in Mariana in 2015, the truck drivers strike in Brazil in 2018, the Philips factory fire im 2000 and the Japan earthquake in 2007, are just a few events that illustrate the impact of risks and uncertainties not only on a single company, but also on several members of its supply chain (Chopra & Sodhi, 2004; Freitas, Silva, & Menezes, 2016; Jüttner; Maklan, 2011).

Thus, this paper contributions are: (1) the understanding, the importance, and the impacts of developing different resilience capabilities to efficiently manage risks and become resilient; (2) deepening a theoretical debate about supply chains resilience dimensions; (3) theoretical development of a resilience package of capabilities including analytical orientation; (4) propose an extended model, that will be empirically tested, in order to verify whether the proposed relationships are statistically significant. (5) make possible to test the explanatory power of the initial model against the extended one. Moreover, empirically tests the change in strengths of relationship with the inclusion of analytical orientation construct, in the initial model, as a component of resilience capability.

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PRINCIPAL-AGENT PROBLEMS IN IMPLEMENTATION OF GHANA'S HEALTH INSURANCE SCHEME

ABSTRACT

principal-agent relationship exists between health service providers and their authority and clients. It asserts that health service providers as 'imperfect agents' of the authority and clients will take actions that aim to maximise profits at the expense of authority and clients (principal). The situation is possible when reimbursement is based on fee-for-service or a diagnosis-related groups. It looks at relationships between health service providers as agents and health insurance authority, and clients as principals in areas of provision of health services, supply of drugs, medicines and reimbursement. Results showed the private health service providers prescribed more drugs and medicines for clients towards profit maximisation (agency) than their public counterparts. Also, it was found that the public health service providers continued to provide health services and drugs despite health insurance authority indebtedness to them exhibiting more stewardship towards health insurance authority. It recommends strict regulations in tariffs/vetting claims and prompt reimbursement.

KEYWORDS | Principal-agent, health service providers, health insurance clients, pharmaceutical supply chain, Tamale Metropolis.

Daniel Dramani Kipo-Sunyehzi
dkipo-sunyehzi@ug.edu.gh
University of Ghana, Legon Centre for International Affairs and Diplomacy, Accra, Ghana

INTRODUCTION

This article focuses on three actors namely National Health Insurance Authority, health service providers and health insurance clients. NHIA is responsible for the implementation of National Health Insurance Scheme (NHIS) in Ghana. In this principal-agent relationship, NHIA (principal) contracts health service providers (agents) to provider healthcare services, drugs and medicines to health insurance clients. Another relationship is between health insurance clients as principal, who expect their agents (NHIA) and health service providers (hospitals and clinics) to provide them health insurance services, supply of drugs and medicines at health facilities. The aim of this study is to examines the implementation of National Health Insurance Scheme (NHIS) in the context of principal-agent relationships in the provision of health services, supply of drugs and medicines and the processes of reimbursement for the services and drugs supplied to health insurance clients in a developing world context of Ghana.

The agency theory provides the theoretical perspective. This study adopts largely a qualitative research design. The main research questions addressed include: do agents shirk responsibility? What about principals? in the implementation of National Health Insurance Scheme in Ghana. The study adds to existing literature on 'agency shirking', it also adds to knowledge in a new direction that, it is not only the agents that 'shirk responsibilities' but principals were found to be engaged in what the authors termed 'shift of responsibility' in the implementation of NHIS in Ghana. This study further adds to public-private partnership in the pharmaceutical supply chain (supply chain management) in a developing world context, with Ghana as a case study. In this regard, it strongly recommends stronger collaboration between public and private sectors and strict monitoring in supply of drugs and medicines in the implementation of NHIS in Ghana. The study attempts to bridge the seemingly gap between public and private sector management and supply of drugs and medicines in retail and bulk distribution as well as managerial interests couple with principal interests. Thus, it examines issues of interests' divergence in both sectors.

Theoretical perspective: Principal-agency theory

The agency theory (principal-agent relationship) provides the theoretical insights for the study. It helps to understand key issues of interests' divergence or incongruences in the supply chain particularly relationships between public and private suppliers, distributors of drugs in Ghana. The incongruences may be due to profit orientations of agents in the provision of services and drugs to health insurance beneficiaries. We look at relationships that exist between principal(s) and agent(s) in implementation of National Health Insurance Scheme (NHIS). The relationship emerges when the 'principal' contracts the 'agent' to perform some task(s) for the principal. The principal in this relationship takes a back stage (passive role) while the agent takes front-line role (active role) of executing principal tasks or duties on behalf of principal. The agent in carrying out the task(s) of principal, takes some decision or action which tend to have some consequences and the consequences in turn affect the welfare or wellbeing of 'both the principal and the agent' (Petersen, 1993, p. 277; 1995, p. 188). The principal-agent relationships abound in many fields of study and daily encounters like teacher-student, doctor-patient, insurer-insured, employer-employee, lawyer-client, owner-manager relationships among others. At organisational levels, such relationships may be between government agency and private organisation(s). In case of this study, this relationship takes the form of public-private health service providers partnership in provision of healthcare. At managerial levels, it takes the form of owner-manager relationship, the manager(s) has managerial skills and the capacity to perform the task of managing the activities of the organisation on behalf of the owner. In this relationship, the agent (manager) is assumed as skilful with expertise to manage or perform the task of the principal (owner of organisation).

The principal-agent relationships are without problems. Petersen (1993; 1995) identifies some two problems of the principal. The first is how to choose the agent-get the right, effective and competent agent or may be face with the risk of wrong agent ('adverse selection'). In situations where the principal cannot observe agent action(s), agent may have the incentive to 'shirk' duties/responsibilities-'asymmetrical information' (Winter, Skou, & Beer, 2008, p. 4). This may undermine the task(s) of the principal. Petersen has two assumptions on human nature on principal-agent: one, 'humans are hyper-rational' based on 'omnipotent calculators/computation'. The second assumption is 'actors behave selfishly and do so with guile' (Petersen, 1995, p. 190). Similarly, Moe (1984) asserts that bureaucratic

agents want to maximise their own interests against their principals. Thus, in the principal-agent relationship, there is issue of self-interest/self-seeking of one actor against the interest of another- 'moral hazards' (Bossert, 1998; Worsham & Gatrell, 2005; Winter, et al., 2008; Erlei & Schenk-Mathes, 2016). Another issue or problem in principal-agent relationship is the procedure use in rewarding the agent (benefits/rewards). It may be based on translation of action (input) into outputs or outcomes or both, or based on financial incentives to change the agent behaviour. Thus, principal and agent decide the kind of reward systems or 'incentives' to operate in their contractual relationships or dealings in agency cost and interests of managers of hospitals, clinics or pharmaceutical companies (Holmstrom & Milgrom, 1991; Pratt & Zeckhauser, 1991; Rees, 1985; Jensen & Meckling, 1976; Kipo, 2011).

On health policies implementation a number of studies have explore the relationships between principals and their agents in service provision, diagnoses, supply chain management and or pharmaceutical supply chains among others across the globe, across countries and or within countries. Nguyen (2011) examines principal-agent relationships in areas of prescribing patterns (drugs/medicines) and behaviours of health service providers' especially private ones.

Brinkerhoff and Bossert (2014) examine principal-agent relationship on behaviours of health system actors as well as their performance problems (multiplicity of social actors in health systems). The first actors being state actors-politicians, policy makers and implementers who work in public sector health bureaucracies like health ministries, agencies and other public sectors. Second actors as health service providers (hospitals, clinics, laboratories et cetera) in public and private sectors. The other actors are the citizens/clients (service users). Brinkerhoff and Bossert (2014) argue reforms that introduce elements of competition among service providers can increase clients' power and increase health service providers' incentives to be more accountable to health service users. Also, service users have the power/capacity to choose among service providers where to access health care while state actors provide policy direction. In Brinkerhoff and Bossert (2014) work, state actor acted as the principal while service providers as agents likewise the citizens as principals in a new public management sense and health service providers as agents satisfying the health needs and demands of the citizens/clients. Brinkerhoff and Bossert (2014) identified three principal-agent problems as: accountability failures, power gap, perverse incentives and service users overconsumption of health services.

Winter et al. (2008) utilised principal-agent theory in the implementation of Danish welfare and employment policy at the front-line level. They conceived national government/parliament as principal while managers of local authorities (local politicians/management) as agents. They found that multiple principals created 'conflicting loyalties' of front-line workers to either superiors (national policy mandates) or keep to the preferences of local politicians/management. Bossert (1998) applied the principal-agent in decentralisation of health systems in developing countries with Ministry of Health as principal (initiator of health policy objectives) while the local authorities act as agents. The work focuses on what happens at the centre and periphery. Bossert (1998) work implies that centre (principal) should focus on designing appropriate health policies with right communication systems, incentives to monitor periphery to achieve goals. Nguyen (2011) also looked at principal-agent relationship issues or problems in health care in a developing country perspective 'from prescribing patterns of private providers' in Vietnam. This article focuses on principal-agent relationship in public-private health providers in Ghana.

Pharmaceutical supply chain

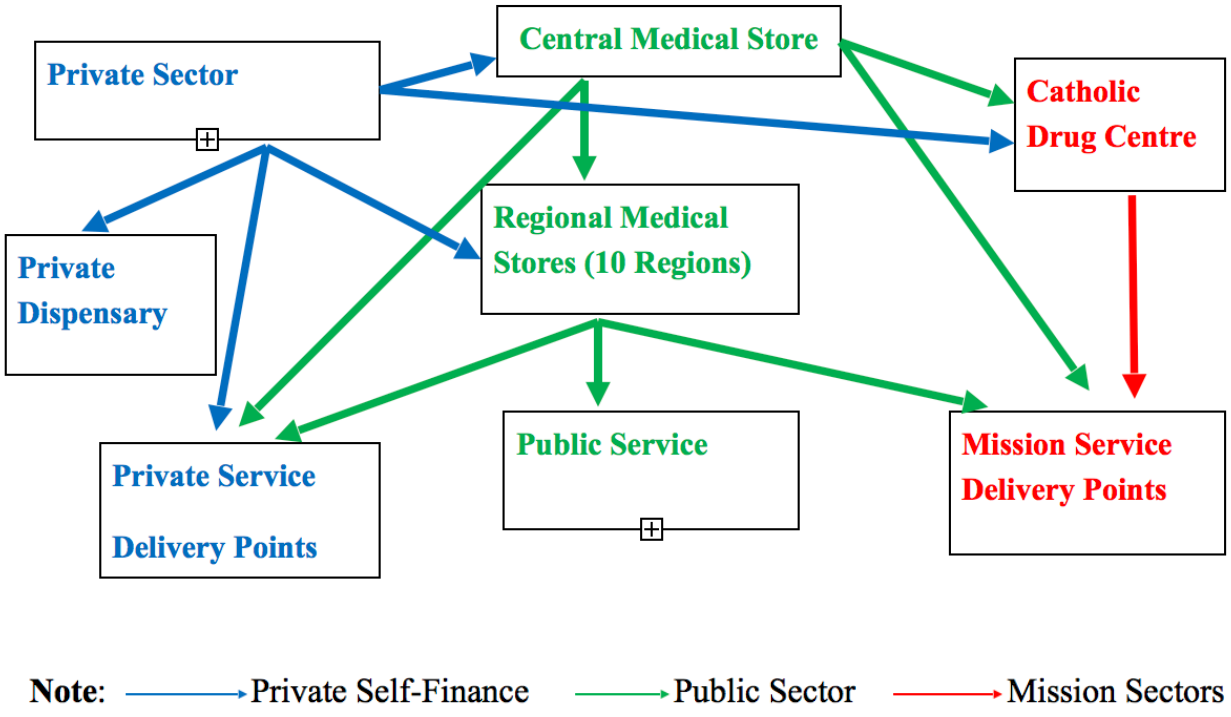
Pharmaceutical Supply Chain (PSC) is the medium through which essential pharmaceuticals are delivered to the end-consumers or end-users at the right quality, right time and at the right place (Enyinda & Tolliver, 2009; Mckabe, 2009). Pharmaceutical Supply Chains (PSCs) are 'major drivers' of the health care sector and their effective management is crucial in healthcare system (Narayana, Pati, & Vrat, 2014). All over the world the public sector alone cannot meet the health needs of the public in terms of supply and distribution of pharmaceutical products. Thus, there is the need for private sector engagement in the supply and distribution of drugs and medicines to complement 'state-run drug procurement and distribution systems' more especially in Africa (Ballou-Aares et al 2008; Mckabe, 2009).

Pharmaceutical supply chain in Ghana

Pharmaceutical supply chain in Ghana is 'complex and interconnected', it involves interaction between the public, private self-financed and private faith-

based sectors. Public-private supply chain is two-directional: The Public Procurement Act (2003) permits public health providers to buy medicines/drugs directly from private sector suppliers under certain conditions (Government of Ghana, 2003b) and private self-financed and private faith-based health providers. The faith-based health providers are the religious-Christian/Muslim health service providers, they can also purchase from the Central Medical Store (CMS)-public source. CMS (located in Tema near Accra) supplies all public hospitals and clinics medicines through the ten (10) Regional Medical Stores (RMSs) for healthcare service delivery as well as private sector health care facilities in Ghana. In this respect, Seiter and Gyansa-Lotterodt (2008) argue that some RMSs in Ghana purchase drugs and medicines up to 80% from the private sector. They identified some challenges in private sector particularly the 'informal sector' where a number of unlicensed or unregulated drugs and medicines are sold to end-consumers/end-users (patients). This exposes the end-consumers (patients) in Ghana to substandard, counterfeit or low-quality drugs/medications. Despite these challenges, the private sector supply chain helps to fill some lapses, gaps and deficiencies in the public sector supply chain. The public-sector supply chain also has some weaknesses such as 'bottle necks and persistent drug stock outs' at health care facilities in Ghana (Ballou-Aares et al., 2008). Figure 1 illustrates Ghana's pharmaceutical supply chain (product flows) between public and private sectors.

Figure 1. Supply Chain (product flows) between



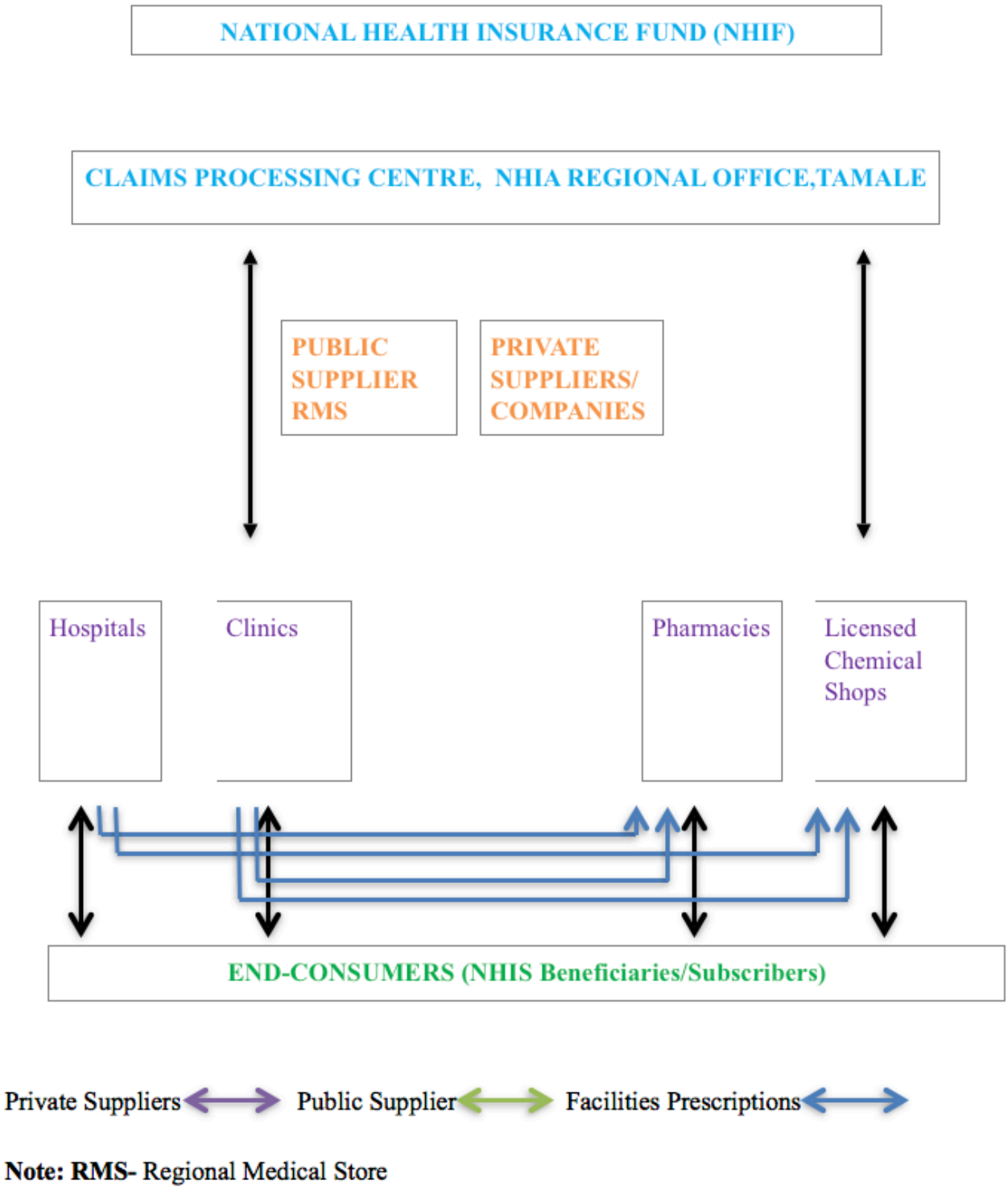
Source: Developed from Ballou-Aares et al, 2008

Figure 1 shows the three main players in pharmaceutical supply chain in Ghana. The extreme *left* is the private self-finance sector which supplies thousands of private dispensaries, hospitals, clinics, maternity homes. The public sector (*middle*) shows CMS supplies all 10 RMSs, which then supply all public service delivery points (public hospitals, clinics) as well as mission and private self-finance sectors. The mission/faith sector at the *extreme right* supplies mission service delivery points and sometime supply public and private self-finance sectors in Ghana.

Pharmaceutical Supply Chain and NHIS Payment Mechanisms in Tamale Metropolis

In Tamale Metropolis, the Claims Processing Centre at NHIA regional office handles claims issues. The local level pharmaceutical supply chain and claims payment system is in Figure 2.

Figure 2. Pharmaceutical Supply Chain and NHIS Claims Payment System in Tamale



Note: RMS- Regional Medical Store

From Figure 2, the main source of funding for implementation of NHIS is the *National Health Insurance Fund (NHIF)* which is located and administered at the national capital (Accra). The funds are release from the top to NHIA regional or district offices for payments as subsidies (for people exempted from payment of annual claims) and re-insurance (other cost/expenses). Besides the NHIF other local level funds include payment of premiums and registration fees. The Claims Processing Centre (CPC) vets all claims submitted by health service providers in Tamale Metropolis and pay monthly claims into bank accounts of public and private health service provider. The health service providers monthly claims shall be paid 'within four weeks by schemes' (GoG, 2003, p. 17) or for a period 'determined by scheme and service providers' (GoG, 2012, p. 39). Public and private health service providers (clinics, hospitals, pharmacies and licensed chemical shops) purchase (buy) the pharmaceutical products from private suppliers or companies or from public suppliers (Regional Medical Stores) and stock their pharmacies or dispensaries to be provided to health insurance clients. Hospitals, clinics, pharmacies and licensed chemical shops are the Service Delivery Points (SDPs) who provide pharmaceutical products (drugs/medicines) to end-consumers (health insurance clients) in the implementation of NHIS at local level in Ghana. This shows the local level pharmaceutical supply chain.

RESEARCH METHODOLOGY: DATA COLLECTION TECHNIQUES AND ANALYSIS

This study was conducted in an urban setting of Ghana (Tamale Metropolis) with a population of 371,351 based on 2010 population and housing census (Ghana Statistical Services [GSS], 2012). Our choice of Tamale Metropolis is premise on its cosmopolitan nature and the city with the largest number of accredited health service providers in North of Ghana. We used duration, and number of services provided criteria to select four health service providers. Beside the four health service providers, we selected some pharmacies, pharmaceutical companies, suppliers in public-private supply chain. Table 1 shows the selected health service providers, suppliers and retailers in implementation of National Health Insurance Scheme (NHIS) in Tamale Metropolis.

Table 1. Selected NHIS Health Service Providers, Suppliers and Retailers

Health Service Providers	Ownership	Suppliers and Retailers	Ownership
West Hospital	Public	Regional Medical Store	Public
SDA Hospital	Private	Ernest Chemists	Private
Bilpeila Health Centre/Clinic	Public	Opac Drug House/Pharmacy	Private
Haj Adams Clinic	Private	Peekay Gombi Pharmacy	Private
		Tobinco Pharmaceuticals Ltd	Private
		S.M. Licensed Chemical Shop	Private

Note: S.M-Seidu Mashud

Most studies on the pharmaceutical supply chain adopt quantitative research methods and data sources like (Shah, 2004; Mckabe, 2009; Nguyen, 2011; Narayana et al, 2014). Our choice of qualitative methods of data collection and analysis is to help us explain this phenomenon better. Our use of in-depth interviews and focus group discussion enabled us interact with participants in their 'natural setting' (Yin, 2014). We interviewed pharmacists at their service delivery points, pharmaceutical product suppliers in their offices, reach out with licensed chemical shop dealers on-site, health service providers at workplace and then meeting various health insurance clients at homes, health insurance offices and at service delivery points in Tamale Metropolis. There have been many studies on Ghana's health insurance as well as studies on pharmaceutical supply chain like Ballou-Aares et al, 2008; Catherine et al, 2008; Mckabe, 2009; Makinen, Sealy, Bitran, Adjei, and Munoz, 2011). But not many studies on the principal-agent problems in the implementation of NHIS in Ghana. In contributing to the principal-agent problems in the implementation of NHIS, we specifically focus on patterns of prescribing and dispensing of drugs and medicines to health insurance clients in Ghana. The reason or motive for examining patterns of prescription of drugs and medicines from medical practitioners and dispens-

ing of drugs and medicines from pharmacies and drug stores aim to solicit the views of medical doctors, physician assistants and pharmacists on the administration of drugs. Moreover, we aim to get better understanding of the supply chain from both public and private service providers perspectives. Most literature on the principal-agent problems or relationships come from the western or developed countries, we are hopeful that our research or study will contribute to the little literature in the developing world especially Ghana. This area of research and the data collection strategies and analysis will hopefully add to the understanding of the relationships that exist between the two principals (NHIA and clients) and their agent (health service providers- hospitals, clinics). Qualitative research strategy is multi-method in focus, interpretive and naturalistic in approach.

Also, qualitative data provides useful insights into human behaviours. Such data sources include collecting life stories, personal experiences, interviews, historical, visual texts, observations, documentation and physical artefacts (Twumasi, 2001; Gray, 2009; Bryman, 2012; Yin, 2014).

We used 'purposive sampling method to select participants (health insurance officials, service providers officials and health insurance clients). We consciously selected the insurance clients based on categories through 'quota sampling' technique' (Twumasi, 2001, p. 28). This technique enabled us to have the various categories from contributors (formal/informal sectors) and those exempted from paying annual premium (children and those below 18 years, pregnant women, the aged (70 years and above), core poor in society (indigents) and pensioners (social security). The categorisation of beneficiaries was done in line with the health insurance policy documents; thus, we took those categories from the health insurance policy documents (GoG, 2003; 2012). To enable us understand task of the principal (NHIA), we solicited the views of health insurance officials at district and regional levels. Officials handling claims on drugs and medicines at the claims processing centre and officials handling registration and renewals of clients. We also sought the views of agents (health service providers-officials in hospitals, clinics, pharmacies, licensed chemical shops, public-private pharmaceutical product suppliers and retailers). We probed during interviews, we also used both 'closed and open-ended questions' in our interview guides. We administered the semi-structured questions in the study area (Bryman, 2012). In doing so, we created a friendly atmosphere for participants to share their life stories, experiences on supply of drugs and medicines, reimbursement and the problems they encounter in the daily implementation of NHIS in Tamale Metropolis. Table 2 illustrates the selected participants. Information obtained from various sources including interviews were analysed through coding, transcription, typing and using direct quotes, as well as content analysis along thematic areas. Towards 'reliability' of findings, we used data triangulation/multiple sources (Yin 2014) and 'credibility' (Zhang & Shaw, 2012) study research design was rigorous and back with theory. These validity strategies were used: 'member checking' participants having an opportunity to determine the accuracy of fieldwork information, this was possible due to 12 months fieldwork. We used 'rich thick description' with participants shared experiences and reliability procedures like transcription as we carefully translated local languages into English, 107 participants in all.

Table 2. Categories of Participants

Categories	Service Providers	NHIA Officials	Suppliers & Retailers	NHIS Exempt Group	NHIS Contributors	**Total**
Number	8	3	6	12	8	**37**

EMPIRICAL EVIDENCE: RESULTS/ FINDINGS

This study is guided by the agency theory (principal-agent relationships) in provision of health services and the supply of drugs and medicines to health insurance clients in Ghana. For 'clarity of results' (Zhang & Shaw, 2012), we categorised findings along major themes in answering our research questions. Results, is followed with discussions of findings with theoretical insight.

Relationship between health service providers and suppliers of drugs and medicines

The questions asked focused the on suppliers of pharmaceutical products as in Figure 3 and the terms of payments. We tried to find out from health service providers (clinics/hospitals) where they take their pharmaceutical products from and how they pay their suppliers. The responses were mixed between the public and private health service providers. The public clinic officials (pharmacists/administrators) indicated that most of their pharmaceutical products came from Regional Medical Store (public supplier) through Ghana Health Service (GHS) Metropolitan Health Management Team (MHMT). The private clinic officials indicated that they have more suppliers to procure drugs and medicines. Also, they said the private clinic is free to procure drugs and medicines from the public supplier (RMS) and the numerous private sector suppliers.

On the two hospitals, we interviewed two officials, one in general administration and the other in the pharmacy unit. The public hospital main supplier of pharmaceutical products is Regional Medical Store (RMS). The public hospital administrative staff indicated that they had to follow procurement rules strictly to enable them procure other pharmaceutical products from private sector suppliers when the main public supplier (RMS) is not able to meet all their product needs. A pharmacist in private hospital revealed that they often take their supplies from three sources namely Ghana Adventist Health Services (GAHS), Regional Medical Store (RMS) and the various suppliers in private sector. We noted less bureaucracy in private hospital procurement.

We also made efforts to reach out with the main suppliers of pharmaceutical products on how they work with health service providers in the implementation of NHIS in Tamale Metropolis. The various pharmaceutical companies and other suppliers indicated that they prefer inter-bank payments through use of cheques than cash payments. We realised that due to fear of robbery, most suppliers especially salesmen preferred payments through the banks than cash payments.

Relationship between Principal (NHIA) and Agent (Health Service Providers)

All interviews and documentations were obtained from accredited facilities and their staff. The four selected health service providers received accreditation for the past years and have since been reaccredited periodically in line with the National Health Insurance Acts, 2003 and 2012 as well as the legislative instrument (1809), 2004 (GoG, 2003; 2004; 2012). The public hospital and clinic received some 'automatic' accreditation license from the National Health Insurance Authority (to operate NHIS in 2005 while the private clinic and hospital applied for accreditation and received 'provisional' accreditation license in 2005 to implement NHIS in the Tamale Metropolis of Ghana. However, this practice has changed since the passage of the new act (Act 852) passed in 2012 which require that both public and private health service providers must be credentialed (accredited) by NHIA before they implement NHIS in Ghana.

It is required for health service providers (agents) to submit their monthly claims to the NHIA (principal). The NHIA is expected to vet the monthly claims thoroughly and reimburse health service providers. Act 650 (2003) require NHIA to reimburse monthly claims within 4 weeks upon receipt of claims while Act 852 (2012) require that reimbursement should be made within an agreeable period between NHIA and health service providers. During interviews, we noted that both agreed that payments should be made within reasonable periods without exceeding six months after submission of claims to NHIA. Table 3 illustrates the responses (direct quotes) of participants (officials of NHIA as principal, and health service providers as agents).

Table 3. Direct Quotes from Participants

1. Public hospital pharmacist	"My bro health insurance is the surest way to health care, without it many lives will be lost. It is a guarantee for life once one subscribes to it. For the hospitals it has reduce fear for service utilisation and that led to increase patronage for health services. Drugs that the poor cannot buy with cash they get them free of charge so what is more than this? But do you know the sad story of health insurance? It is delays in claims payments".
2. Public hospital pharmacist	"The delays though mild in the public sector yet contribute to stock-outs in many pharmacies and dispensaries because we need cash to procure some essential drugs since we cannot get all from the regional medical store".
3. Private hospital pharmacist	We like the health insurance scheme because it is a major source of revenue for the hospital; it also helps the poor to access healthcare services and have free access to drugs and other medications. However, payments of claims are the biggest problem. Sometimes it takes over six months without payments. Can you imagine how the hospital will manage to buy drugs and pay its staff salaries and other incentives? How can you provide services and drugs and will have to wait for over six months to be paid? That is bad and this affects us a lot. No wonder we sometimes go on strike to get our claims".
4. Public clinic administrative officer	"We are part of GHS we are paid by the state so why should we go on to boycott health insurance, we get our salaries and products from GHS".
5. Private clinic physician assistant	"What is the point embarking on strikes and losing lots of revenue? The more you refused to provide services and drugs to insurance clients the more you lose revenue to the facility that's why we don't embark on strikes".
6. Peekay Gombi pharmacist	"Eeeii we usually receive prescription forms from patients from all hospitals and clinics in Tamale. We don't discriminate between patients whether from public or private facility, once the prescription form is signed and stamped that is all, we accept it and provide the patients the drugs as prescribed. However, frequent delays in payments of claims are our biggest problems".
7. Licensed chemical shop seller	"Health insurance people don't often visit our drug store but those who come with prescription forms, we do provide them the needed drugs but delays in reimbursement is what affect our revenue and affect both quantity and quality of drugs. It is too bad that it can take over six months".
8. Metropolis NHIA officer	"We are very much aware of how some facilities refused to dispense drugs to clients but take their prescription forms to demand claims from us".
9. Metropolis NHIA line manager	"National health insurance fund is main source of funding from national, those we generate locally: registrations and payments of annual premiums. Most people are interested in health insurance and they do register and renew their membership. Though we cannot say it openly there is secret politics"
10. Regional NHIA officer at Claims Processing Centre (CPC, Tamale)	"We usually vet the monthly claims of facilities to see that right prescriptions and tariffs are charge. Also, we check to see if subscribers indeed visited their facilities. Payments of claims take two forms: services rendered and drugs supplied to subscribers. Deductions or additions are given to facilities for wrong charges or for fairness. On payments we sometime encounter delays due to rigid vetting at processing centre to check fraud. We always try to avoid non-payments beyond three months and not exceeding six months".

We asked questions in relation to reimbursement from NHIA for drugs and medicines provided to health insurance clients. These questions were directed to the principal (NHIA) regional and district officials. The same questions were also directed to the agents (health service providers). The responses of the NHIA officials are in Table 3, quotes 8-10. They indicated that they have fulfilled their contractual agreements through the rigorous vetting of claims, checking wrong charges and multiple entries as well as wrong application of tariffs on drugs and medicines. In addition, the principal (NHIA) indicated that periodic clinical audits are conducted as additional measures to check fraud and abuses from their agents (health service providers-hospitals/clinics and other service providers). NHIA officials admitted to delays in reimbursement for services, drugs and medicines but associated such delays to rigorous vetting and monitoring on agents.

On the other hand, the agents from both public and private indicated that their principal (NHIA) has failed in carrying out its contractual agreements such as payments within four weeks or not exceeding six months upon receipt of health service providers claims. The agents' responses to delays and non-payments of claims for months or over six months in Table 3, quotes 1-3, 6-7). But the agents were divided on the use of strikes or protests to demand for prompt payments.

While the faith-based hospital joined other Christian Health Association of Ghana (CHAG) to embarked on strikes across Ghana in 2013 and 2014, other private suppliers of drugs and medicines joined the strikes (Daily Graphic Newspaper publications on July, 2, 2014, p. 11) and other online publications (Ghanaweb News). Most private health service providers and pharmaceutical companies joined strike to boycott NHIS. But private for-profit clinic declined to join other private groups on strikes on grounds that the facility will lose revenue if it embarks on strike (see Table 3, quote 5). Public service providers did not embark on strikes as state health providers (Table 3, quote 4). They received more pharmaceutical products from the public supplier-regional medical store. We found that the private health service providers felt the delays in reimbursement more because they had to pay their workers salaries, procure drugs and medicines on their own. Thus, we noted more financial pressure was on the private sector health providers than public ones.

Despite the challenges or problems between the principal and the agents in reimbursement, we asked if there were some prospects in the implementation of NHIS. The responses of officials of the two hospitals showed that NHIS is a very good social intervention programme that has benefited the people of Ghana in terms of access to healthcare services and drugs. It has also contributed to increased patronage for healthcare services thus increased service utilisation. It has removed some financial barriers to healthcare since health insurance clients have free access to number of essential drugs (approved drugs) and wide range of services. Moreover, since the implementation of NHIS, the fear for payments for medical bills especially drugs and admission fees have been removed as such services are part of NHIS benefits package for clients.

Issues of Prescription Forms for Drugs and Medicines in Implementation of NHIS

When health service providers (hospitals and clinics) do not have certain drugs or medicines in their pharmacies or dispensing stores, the health professionals will normally issue a prescription form usually signed and stamped with details of health insurance client. The prescription form is presented to the client to be taken to other accredited pharmacies, licensed chemical shops (drugstore) for drugs and medicines that are out of stock at the hospital or clinic. This medical practice of issuing prescription forms to clients is an effective way of helping health insurance clients to have access to drugs and medicines that are not available at hospitals or clinics visited.

The accredited pharmacies and licensed chemical shops in turn provide health insurance clients drugs and medicines and forward their monthly claims to NHIA for payments. A pharmacist in one accredited pharmacy in Tamale Metropolis (Peekay Gombi Pharmacy) commented on their working relationships with health service providers (hospitals, clinics) and NHIA (Table 3, quote 6). An accredited chemical shop seller confirmed receiving prescription forms (Table 3, quote 7). However, we observed certain bad practices at accredited pharmacies and licensed shops which include the practice of receiving prescription forms without dispensing drugs and medicines to health insurance clients, problems no drugs, demand for some cash payments from clients due to differences in tariffs, the practice of not providing clients all the drugs prescribed by health professionals at hospitals and clinics, and the prac-

tice of 'go and come for drugs the next day'. These were observed at those accredited pharmacies and licensed chemical shops in Tamale.

We then interviewed officials of NHIA to solicit their views on some issues/complaints from four health service providers and the other accredited pharmacies and licensed chemical shops officials. Officials of NHIA admitted to delays in reimbursements and how it can affect quality of services, drugs and medicines but blame some of the accredited health facilities for engaging in malpractices which made them spend more time in vetting claims. Some accredited health service providers/facilities are busily cheating our subscribers and doing wrong things (Table 3, quote 8). Thus, decision to critically examine claims and vet them properly (Table 3, quote 10).

Moreover, NHIA officials at district and regional offices confirmed that some deductions were made on monthly claims of some accredited health service providers/facilities as complained by officials of health service providers. The NHIA officials maintained that those deductions were due to some abuses, errors or fraudulent deals. NHIA officials disagreed that they often owe their agents claims beyond six months contrary to the agreement they had with their agents.

Documentary evidence from the field confirmed deductions of health service providers monthly claims. The national office of NHIA was suspicious of some malpractices at local level across Ghana between local NHIA officials and some health service providers. There was suspicion of connivance between some NHIA officials and health service providers with the feeling that local health insurance officials were not diligent in vetting and verification of monthly claims at local level. In this regard, NHIA instituted *clinical audits* across the country. In the Tamale Metropolis clinical audit took place in March 2010 in which eight health service providers claims were audited. The clinical audit aimed to cross check claims vetted by local level NHIA officials. After the audit it was discovered that a huge amount of GH¢279, 069.81 (72,485.67 USD) was wrongly paid to the eight selected health service providers in 2010. A second clinical audit was conducted in June 2012 in Tamale Metropolis by the national audit team. An amount of GH¢486,268.31 (125,679.33 USD) was deducted from thirteen health service providers. The national audit collected relevant documents including attendance books, monthly claims reports, NHIS attendance registers et cetera. They thoroughly audited them and recommended that all wrongly paid monies be deducted from the affected health service providers claims. The most affected health service providers with more deductions was the private clinic, followed by the private hospital while the least affected was the public clinic (Tamale Metropolitan Mutual Health Insurance Scheme (TMMHIS) Annual Reports, 2010; 2012).

Relationship between Principal (Clients) and Agents (Health Service Providers)

The second principal-agent relationship is between health insurance clients (the principal and health service providers (agents) in the implementation of NHIS in Tamale Metropolis. We solicited the views, opinions and experiences of health insurance clients (end-consumers) of pharmaceutical products on the implementation of NHIS at the local level. We used both in-depth and Focus Groups Discussions (FGDs). The health insurance clients freely expressed their opinions and shared their experiences on the provision of drugs and medicines at the four selected health service providers (hospitals/clinics). The health insurance clients confirmed that they often receive drugs and medicines free from health service providers. Many mentioned of receiving drugs and medicines from accredited pharmacies like Peekay Gombi and Opac Drug House with their prescription forms. Few also mentioned of receiving drugs and medicines from licensed chemical shops in Tamale Metropolis. Some pregnant women interviewed confirmed receiving pregnancy medications without payments at the four health service providers as well as other accredited facilities. We also made on-site observations on the issuing of prescriptions forms and the dispensing of drugs and medicines to health insurance clients (end-users or end-consumers of pharmaceutical products). We noted there were long queues of clients at various Out-Patient Departments (OPDs) pharmacies and dispensaries waiting for drugs and medicines. Our observations confirmed the medical practice that in some instances where some drugs and medicines were not available at facilities pharmacies and dispensaries, prescription forms were issued by medical personnel to their clients to visit other accredited pharmacies and chemical licensed shops. Most responses from end-consumers or end-users of pharmaceutical products showed that private health service providers dispense more ex-

pensive drugs than their public counterparts (Table 4, quotes 2) in implementation of NHIS in Tamale Metropolis in Ghana.

Despite prospects of clients increased access to drugs and medicines and revenue for hospitals and clinics (see Table 4, quotes 10-11) and other accredited pharmacies and licensed chemical shops some clients still shared their frustrations in other areas. These frustrations/problems were noted during the in-depth interviews and FGDs. The health insurance clients indicated that some expensive drugs were either excluded or service providers demanded cash payments for them. Some health insurance clients were of the view that most of the drugs and medicines provided them free were less expensive particularly those obtained from the public sector. These observations revealed that the principal (health insurance clients) were not so happy with the performance of some agents (health service providers) in terms of access to expensive and effective drugs and medicines at point of service delivery (hospitals, clinics other providers).

We also found from the field habits like 'shopping spree' where some health insurance clients (end-users/consumers) visit many health service providers/facilities to be provided with drugs and medicines for other family members or friends (Table 4, quotes 7) at the expense of NHIA. The principal (some clients) abusing the agent (NHIA) through use of other persons insurance cards to access drugs and medicines by fraudulent means. In some extreme cases some incidence of expired drugs and medicines were supplied by health service providers to health insurance clients (end-consumers) especially to the illiterates (those who cannot read English). We observed a similar case at a private pharmacy where the dispensing officer mistakenly dispensed expired drugs to health insurance client and when the client checked expiry date, he quickly returned those drugs. The dispensing officer apologised and promised it will not happen again since expired drugs are often removed from dispensing shelves and wondered why they were left there. If the client was an illiterate he or she would have gone with the expired product. Thus, the agents (health service providers) also abused the principal (clients) in some areas like supply of expired products/supply of less quantity as required. The end-users of pharmaceutical products (clients) responses at both in-depth interviews and FGDs are in Table 4, quotes 1- 9.

Table 4. Interview/FGDs Responses from Beneficiaries and staff of health care facilities

1. Indigent	"They don't respect we the poor ones. I sat here and many people are bypassing me to see the doctor".
2. Pregnant woman	"The drugs we get from facilities especially government clinics and hospitals most of them are cheap para, they don't cost much, expensive drugs like foreign pregnacare plus omega 3 will not be given to insurance people only those with cash will get them".
3. SSNIT contributor	"I don't normally fall ill but had to join health insurance it times of emergency or at periods of no money so it is my social security".
4. Aged	"Some NGOs helped to register me and they come to pick my card for renewals I don't pay pesewas when I go to hospital with health insurance".
5. Pupil (basic level)	"It is my mother who registered me for health insurance, I am always sick of malaria that is why my mother registered me".
6. Premium Payee	"I am a carpenter so I registered for myself, wives and all children, we don't pay money at clinics it is a good insurance for life".
7. Student(secondary)	"In the school we use friends' cards and we us this insurance card for mobile money, also my school authority asked all to register for it".

(continue)

(conclusion)

8. Lamashegu FGD	Most participants complained of long queues at hospitals and clinics with health insurance, poor treatment from facilities. Four supported this while one praised health insurance saying. "it is my survival card when I visit hospital, no fears for medical bills".
9. Moshie-Zongo FGD	Members showed praises on health insurance as when there is no money, one can visit any hospital for drugs and medicines. A group member said this about health insurance "it saves life and reforms life and brings hope to the hopeless with health insurance card".
10. Private facility staff	"Health insurance is the main source of funding; we used money to buy drugs and pay workers and it is far better than cash and carry".
11. Public facility staff	"The people of Ghana are happy for this policy, which is very friendly to poor and vulnerable ones is society for free health care. The poor don't run away from bills".

DISCUSSIONS OF FINDINGS

Principal-Agent Issues and Problems in the Implementation of NHIS

The results or findings confirmed that there is a contractual relationship between the principal (NHIA) and agents (health service providers-the selected hospitals, clinics and other providers) through accreditation and re-accreditation in accordance with health insurance Acts (650; 852).

Findings on prescribing and dispensing patterns for drugs and medicines for health insurance clients from the various private health service providers concur with Moe (1984) assertion that 'bureaucratic agents want to maximise their own interests against their principals'. But this finding was not consistent with those in the public sector. The findings also agree with Nguyen (2011) that private service providers have desire to prescribe and dispense more drugs to insurance holders for profit maximisation. However, such prescribing patterns were not noted with public health service providers. These principal-agent problems were noted between NHIA and health service providers in the area of prescribing and dispensing of drugs and medicines to clients. The private health services providers were more 'self-seeking' or 'selfish' with more moral hazards than their public counterparts, which agrees with a number of studies on agents' self-interests/self-seeking (Worsham & Gatrell, 2005; Winter, et al 2008; Erlei & Schenk-Mathes, 2016). Other problems identified in this study is that the reward system for performance is not clear, this created some mistrust or suspicion between the principal (NHIA) and the agent (service providers).

On the issues of monitoring of the agents (health service providers) by the principal (NHIA), The principal was found proactive in monitoring the actions of the agents in areas of rigorous claims vetting and clinical audits which helped in checking fraudulent acts from some agents. But, on reimbursement for services, drugs and medicines provided by health service providers, we realised that the NHIA as principal was not able to honour the agreement in terms of prompt payments of claims (reimbursement), it was indebted over six months to agents (health service providers). The agents honoured their part by rendering more services, drugs and medicines to clients but principal failed in keeping to its contractual agreement in line with insurance law. This confirmed shifting of responsibilities by the principal-NHIA as it concurs with Holmstrom and Milgrom (1991) and Pratt and Zeckhauser (1991) works on breaches on contractual relationships. The agents (health service providers) on the other hand, we noted breach of trust. For instance, the faith-based private hospital, some private pharmacies and suppliers of drugs and medicines embarked on nationwide strikes, denying clients access to healthcare services. For instance, the Ghana Chamber of Pharmacy (pharmaceutical distributors) on February 10, 2014 decided to withdraw the supply of drugs and medicines to NHIS accredited health service providers across Ghana. This behaviour amounts to 'breach of contract' or 'breach of trust' for their principals (NHIA and cli-

ents). This finding on agents particularly the private health service providers use of strikes to demand payments of claims in Ghana concurs with findings of Fusheini, Marnoch, and Gray, 2016.

We also found problems of 'conflicting loyalties' between the public and private health service providers where public providers were more loyal to NHIA than the private ones in areas of prescriptions, applications of tariffs, invoicing as reflected in both interviews and documentary sources of data (clinical audits). Such finding on 'conflicting loyalties' among the agents at the local level is consistent with Winter, Skou, & Beer (2008) findings in which multiple principals created conflicting loyalties in the implementation of Danish welfare and employment policy at front-line level. At some point the service providers appear loyal to one principal (NHIA or clients). Some abuses were found that affect the implementation of NHIS from health insurance clients in the forms of over-utilisations (frequent visits) in getting drugs for other relatives and friends. Some facilities also engaged in over-invoicing, over-billing, demanding cash payments etc. Some NHIA officials' connivance with facilities to cheat scheme through poor claims vetting.

Implications of findings for policy makers and international audience

The empirical evidence from the field suggests health service providers and medical stores have to strengthen pharmaceutical supply chain networks, build human resource capacity and take measures against pilfering of drugs to prevent frequent stock-outs particularly in public sector. The growing number of private drug suppliers is worrying at the local level with the influx of substandard and counterfeit drugs and medicines and this call for a stronger regulation and control by the pharmacy and drugs authorities in the distribution and retailing outlets. This is in line with McCabe (2009) suggestions for Ghana, Mali and Malawi pharmaceutical sector. Our findings also show that there is persistent pharmaceutical drug stock-outs in public sector (Ballou-Aares et al., 2008 and Makinen et al, 2011). Also, there is too much bureaucratic procedures at public sector and growing numbers of unregulated salesmen, middlemen and drug dealers at the local level. This Narayana, Pati & Vrat (2014), call for effective collaboration between public and private sectors partnerships in purchasing processes and supply chains networks. This study recommends that NHIS need to re-strategize in its payment mechanisms to include capitation systems where healthcare facilities are pre-finance for some particular clients to minimise its indebtedness to service providers. Moreover, there is room for improvement in its recruitment processes to enable the scheme recruit highly qualified and competent staff to vet, to process and manage claims at various claims vetting centres and scheme offices across Ghana. Another problem identified is the politics of recruitment. This study recommends for stringent measures to minimised this practice to get the right personnel to save the scheme from possible collapse from its persistent high indebtedness to health service providers. This study finding on politics concurs with Fusheini Marnoch, and Gray (2016) findings that over-politicization, political interference and poor gate keeping system are key challenges affecting implementation of NHIS in Ghana. Thus, effective gate keeping mechanisms for referrals and prescription is very necessary for NHIS. Similarly, effective control measures should be instituted against abuses by clients by limiting the number times they will visit health service providers and with strict checking of clients' identities before services and provision of drugs at facilities. Financial malpractices by both health insurance officials and health service providers should be severely punished to deter others.

Contribution

This study found a new dimension, that not only agents 'shirk their responsibilities' but it noted a new pattern with principal engaged in 'shift of responsibility'. We recommend that future research or researchers would examine this new dimension and pattern of behaviour between principal(s) and agent(s) in supply chain management in Ghana or elsewhere in the world.

This study may have a geographic limitation but the findings can be transferable to other places with similar settings. It adopted largely a qualitative research approach which focuses more on 'analytical generalization' rather than 'statistical generalization' (Yin, 2014, p. 48).

CONCLUSION

Health policy formulation and design factors seriously need to be considered in order to make health policies more implementable. Framers of NHIS should have assessed the relationships between principals (NHIA) and agents (health service providers) in terms of incentives, profit maximisation and quality assurance in order to select the right agents. This

suggest that rigorous accreditation process is needed before granting health facilities license to implement NHIS. This will help to get agents whose interests and goals are in congruence with NHIS in Ghana. We recommend strict regulations in tariffs, vetting of claims and prompt claims reimbursement.

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THE BRAZILIAN OCEAN FREIGHT OSCILLATION: THE EXPERTS' EXPLANATION TO THE USA, EUROPE AND CHINA TRADE

ABSTRACT

This study aimed to identify the variables that contribute to the oscillation of the international ocean freight of the Brazilian trade of containerized cargoes. The ocean freight from and to East Coast of United States, Northern Europe and China to Brazil was studied by a qualitative approach through in-depth interviews with a panel of seven experts in charge of pricing the international ocean freight in the largest international shipping companies operating in Brazil. After a first round with the experts, a table that tried to capture the causal relationship among variables and their influence in Brazilian ocean freight was developed. In a second round of interviews, the final table was submitted to the judgment of the experts. Considering the experts' opinion on the trade routes studied, it was noticed that the relationship between supply and demand with ocean freight is the variable that influences freight rates in Brazil's trade the most. Other variables such as vessels capacity, operating costs and competitors are among the variables that experts have identified as those that most contribute in Brazilian ocean freight oscillation.

KEYWORDS | Ocean freight, Brazilian maritime freight, containerized cargoes, Brazilian international trade, international logistics.

Felipe Búrigo Balthazar
felipe.balthazar@expeditors.com

Marcelo André Machado
mmachado@unisinos.br

Guilherme Luís Roehe Vaccaro
guilhermev@unisinos.br
Universidade do Vale do Rio dos Sinos, São Leopoldo, RS, Brazil

INTRODUCTION

Many companies have realized the importance of trading products, raw materials, or even services at lower costs, higher quality, and wider variety. In this sense, the question is not about whether to look for more international resources or not, but how to manage this process and make it more efficient (Aykol, Palihawadana, & Leonidou, 2013; Grama, 2014; Trent & Monczka, 2003). Therefore, exporters and importers are more attentive to the costs involved in these processes, in order to make their products more competitive and, by logistic management, to establish policies that enable them to reduce costs and improve service level to the customer (Bygballe, Bø, & Grønland, 2012).

Transport costs represent a critical component of importation and exportation prices, and influence the development of a supplier or a customer (Anderson & Van Wincoop, 2004; Monroe et al., 2014). Freight rates bear a larger importance, compared to tax barriers (Binkley & Harrer, 1981; Hummels, 2001; Jacks & Pendakur, 2010). According to Fleury, Wanke, and Figueiredo (2012), generally production and marketing costs represent more than 70% of a company's revenues, while logistics costs stand at 19%. In addition, Ballou (2004) declares that 60% of logistic expenses originate in transportation, which explains the importance of managing freight rates, whether in domestic or international routes. These percent values prove that logistic expenses play a considerable part in the composition of the total cost of a product, which is why such values are the object of consistent reduction efforts as a means to improve profit margins.

On the other hand, in 2015, dry cargo shipments accounted for about 71% of total seaborne trade volumes, which means that "maritime transport is the backbone of globalization and lies at the heart of cross-border transport networks that support supply chains and enable international trade" (UNCTAD, 2016).

According to the Brazilian Ministry of Development, Industry, and Foreign Trade (MDIC, 2017), by the end of 2015, 90% of Brazil's international trade was transported by sea. Ocean freights placed on these imports and exports are formed by several variables. Although several studies have investigated some of these variables, such as the kind of goods shipped (Ho, Chiu, Chung, & Lee, 2017; Ortúzar & Willumsen, 1994), supply and demand (Jacks & Pendakur, 2010; Notteboom & Rodrigue, 2008; Ortúzar & Willumsen, 1994; Stopford, 2009), distance covered by the vessel (Banomyong, 2005; Hesse & Rodrigue 2004; Malchow & Kanafani, 2004), and vessel capacity (Leach, 2014; Notteboom & Rodrigue, 2008; Stopford, 1997), there are not many studies that addressed the variables behind the oscillations in international ocean freight rates set for exports and imports in the main routes serving emerging markets as Brazil.

The Brazilian Ministry of Development, Industry, and Foreign Trade (MDIC, 2017) indicates that the main economic regions that import to or export from Brazil are North America, Europe, and China. For Mongelluzzo (2013), the world's largest ports on a container flow basis are located in these continents. In the top 50 list, North America is represented by the Los Angeles, Long Beach, and New York ports with 8.08 million, 6.05 million, and 5.53 million of twenty-foot equivalent units (TEUs), respectively. In Europe, the largest ports are in the north, and include the ports of Rotterdam, Hamburg, and Antwerp with 11.87, 8.86, and 8.64 million TEUs, in that order. The Shanghai, Singapore, and Hong Kong ports are the main ones in Asia with 32.53, 31.65, and 32.13 million TEUs. In the same list, Brazil is represented by the port of Santos, which runs around 3.17 million TEUs. For this reason, Santos was chosen as a destination port, while Shanghai, Rotterdam, and New York (since it is located on the east cost of the USA) were selected as main ports in the analysis of freight volumes in the present study.

In this scenario, this study identified the variables that influence on the oscillations in international ocean freight rates for Brazilian containerized trade with its major markets. The investigation considered the perspective of the three largest cargo trade volumes with Brazil: the USA East Coast, Northern Europe, and China. The views and notions of a panel of experts active in three main company classes were analyzed: shipowners, co-loaders, and freight forwarders. The inclusion of these experts in different sectors helped understand the perceptions held by organizations that, despite sharing the same objective in terms of cargo transportation, could see the pricing of ocean freight rates from different points of view.

This article presents, first, a review of the theoretical background on the subject and the contribution of the variables that influence on the oscillations in

international ocean freight rates. Secondly, it will be discussed the methodological aspects to collect and analyze the data. After that, the data analysis obtained for the freight levels and the variables that influence the most on the oscillations observed are presented, as well tries to offer a proposal of a causal relationship among variables that influence freight in the trades studied. Finally, the implications of these variables are discussed.

THEORETICAL BACKGROUND

The supply chain and logistics

The globalization process has left a trail of economic uncertainties (Jacks & Pendakur, 2010). The increasing exchange of goods and services across nations has substantially acerbated interdependence and economic volatility. Local changes and crises bear immediate consequences and tend to spread globally.

Revisions in dollar exchange systems, recession, new international trade regulations, and higher oil prices are some of the uncertainty factors that affect a globalized economy on a daily basis. For logistics, which has to act based on a prediction of demand, producing and placing the correct product in the right place at the right time and at a fair price, increased economic uncertainties elicit significant difficulties to predict sales and plan activities (Fleury et al., 2012; Hesse & Rodrigue, 2004).

The supply chain, according to Bowersox, Cooper, Closs, and Bowersox (2014), encompasses companies that cooperate in order to leverage a strategic position and to improve operational efficiency. Ballou (2004) summarizes logistics and the supply chain as a "set of functional activities (transportation, inventory control, etc.) that repeat numerous times along the channel through which raw materials are converted into finished products, to which value is added in the eyes of the customer" (p. 29).

Since logistics is part of the supply chain, Bowersox et al. (2014) define it as the effort required to transfer and place an inventory in the supply chain. Banomyong (2005) agrees, adding that logistic management is an integrative process that aims to optimize the flow of materials and inputs provided by suppliers in the whole organization in order to meet customer's expectations. It is by a logistic process that materials travel inside the production capacity in an industrialized country, that products are distributed to consumers, and that value is generated to customers, suppliers, and any other stakeholder (Bygballe et al., 2012; Monroe, Teets, & Martin, 2014).

The international ocean shipping system

The role played by transportation in a logistics system is more complex than that of the transport of goods to customers (Zeng & Rosetti, 2003). This complexity may take effect only through a highly qualified management team. A well-managed system affords to transport goods to the right place, at the right time, aiming to meet the customers' need. It is transportation that helps promote efficacy, establishing a link between producers and consumers (Daividsson, Henesey, Ramstedt, Törnquist, & Wernstedt, 2005). Therefore, transportation is the basis of efficiency and savings in corporate logistics, and enhances other functions of the logistics system (Ballou, 2004; Grama, 2014). In addition, a good transportation system in a logistics network is beneficial not only to the quality of service, but also to a company's competition potential (Tseng, Yue, & Taylor, 2005).

It is widely accepted that water is the oldest means of transport. Ancient sailboats were replaced by steamboats in the XVIII century, and by diesel-propelled vessels around 1920's (Bowersox et al., 2014). Ships were first used to transport containers in 1956, when Malcolm McClean shipped the first cargo trailers towed by a 60-TEU World War II tanker, sailing from Newark, New Jersey, to Houston, Texas. Until then, most cargoes were transported loosely on ships, placed in wooden structures whose aim was to enable to hoist and to move goods by cranes on ports and on ships (Stopford, 1997). The result was that cargo ships spent about two thirds of operational time on ports, and that handling costs reached approximately one fourth of the total expenses. With increasing cargo volumes, this mode of operation became unfeasible both operationally and economically (Binkley & Harrer, 1981; Notteboom & Rodrigue, 2008).

The main advantage of ocean transport lies in the possibility to ship extremely large cargoes, besides lower costs when compared to airfreight (Ballou, 2006; Bowersox et al., 2014). As drawbacks, Tseng et al. (2005) highlight the longer delivery times, apart from the need to schedule mooring operations depending on weather factors. Other negative aspects include the distance between ports and production centers, and the need to invest in robust packaging solutions in order to protect goods, especially

against possible damage caused by mishandling during loading and unloading operations.

Ocean shipping costs to containerized cargoes

The advent of container transport in the 1960s changed irreversibly the environment of the global transportation business and it has become increasingly competitive due to the economic globalization (Finke & Kotzab, 2017; Fung, Cheng, & Qiu, 2003; Notteboom & Rodrigue, 2008). At the same time, along with market uncertainty, freight tariffs have been one of the highest priorities for importers and exporters since 2000, because container shipping lines have provoked great bargaining over price (Ho et al., 2017). In this sense, shipping rates can be defined as the fees charged by transportation companies when providing services, that is, the payment to cover the costs of transportation between two locations and the expenses associated with the maintenance of a traveling inventory (Grama, 2014; Sahin, Yilmaz, Ust, Guneri, & Gulsun, 2007).

The revenue of container shipping firms and, therefore, the freight price, is dependent on an interaction between price and quantity. That means the freight rate represents the price, and the quantity refers to the spaces used in a container vessel. So, the balance must be reached to offer a reasonable freight and, at same time, to transport cargoes that occupy the spaces in the vessel (Notteboom & Rodrigue, 2008; Tang & Sun, 2018).

In this sense, freight all kinds (FAK) is a general rate defined by shipowners to classify any goods being transported. As a rule, FAK is higher than the values charged to ship goods at loading, exactly to cover for all cargo types, including dry cargoes (Bowersox et al., 2014; Maloni, Paul, & Gligor, 2003). Dry cargo is the term used to describe materials that do not need special care during loading. As opposed to gaseous or liquid loads, dry cargoes may be shipped in containers with no special temperature control measures. Dry cargoes are several types of cargo, such as dry finished products, metals (such as iron and steel), and even some heat and cold-tolerant grains (Ballou, 2004; Bowersox et al., 2014; Ho et al., 2007).

On the other hand, there are many costs that affect container freight that are not linked to the cost of shipping the goods. One of the most common is the terminal handling charges (THC) that are fees charged by shipping lines to cover costs of moving containers from the terminals to the ships (Fung et al., 2003; Slack & Gouvernal, 2011) Another important cost for containers is regarding the storage of empty containers in the terminal or in another warehouse abroad, while awaiting its reuse, as well as the costs of management and organization of the container reposition (Finke & Kotzab, 2017; Steenken, Voß, & Stahlbock, 2004).

Nevertheless, in pricing ocean freight rates, it was observed that several factors must be considered and some of these variables were discussed in several studies published in the past 20 years. So we have tried to summarize the main constructs that, at some point, interact with freight rates and have the power to provoke an oscillation of its level. A review of those studies enabled the identification of 12 variables to be analyzed by the panel of experts, with the purpose of understanding the contribution of these aspects to the oscillations in freight rates, according to Exhibition 1.

Exhibition 1. Variables that influence ocean freight rates

Product/ Commodity	Several factors, based on density, packaging, facility to handle, and risks affect the freight rate of a product.	Ballou (2004), Bowersox et al. (2014), Fung et al. (2003), Ortúzar and Willumsen (1994)
Cargo weight and volume	The heavier the container, the higher the shipping costs. In addition, shipowners have to identify the best location of a container on board to balance it with other containers on the deck. Light cargoes are preferred, since they consume less fuel and cause less concern to the total weight of the ship.	Ballou (2004), Bowersox et al. (2014), Notteboom & Rodrigue (2008), Steenken et al. (2004), Tang and Sun (2018)

(continue)

(conclusion)

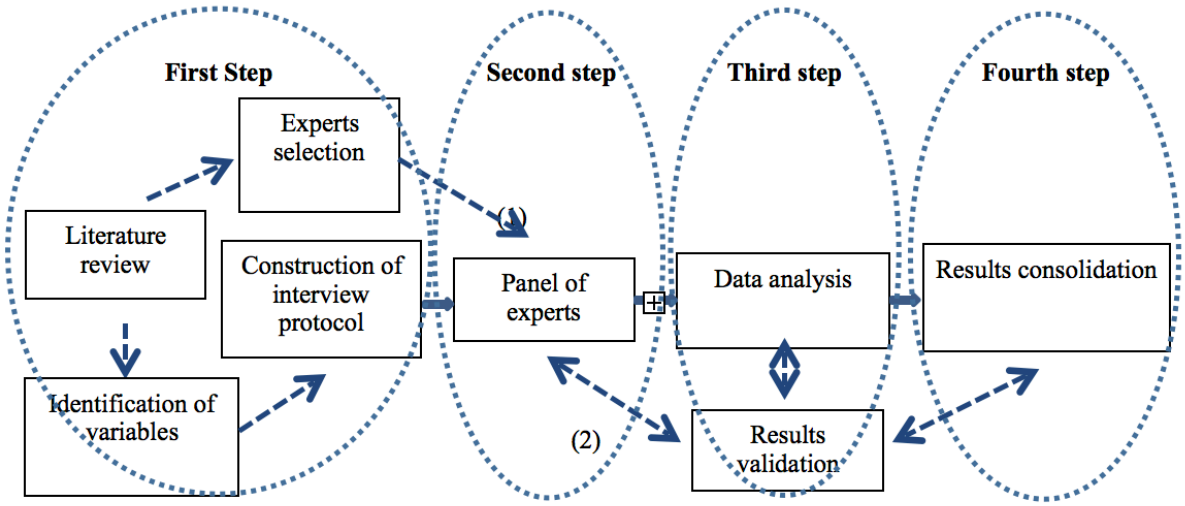
Supply and demand	Demand influences directly the freight rates, since it involves the market supply and demand relationships. In other words, when supply is high and demand is low, rates tend to go down, and vice-versa.	Ballou (2004), Ortúzar and Willumsen (1994), Sahin et al. (2007), Stopford (2009), Zeng and Rossetti (2003)
Distance sailed	A large number of the studies reviewed cover the composition of freight rate considering distance as the main factor in the definition of rates, independently on transport mode.	Banomyong (2005), Bowersox et al. (2014), Ho et al. (2017), Maloni et al. (2013), Malchow and Kanafani (2004), Hesse and Rodrigue (2004)
Cargo size/number of containers	When shipowners price a loading operation of one single container, the rates charged are normally excluded from the general FAK classification of product and rates. However, when cargo size and number of containers are known, a differentiated pricing strategy is adopted, if the other variables with the goods transported allow reducing ocean freight rates.	Florentino (2010), Notteboom and Rodrigue (2008), Slack & Gouvernal (2011), Zeng and Rossetti (2003)
Operational costs	Operational costs may affect the freight rate in different routes distinctively, since regional differences, such as the interaction between demand and supply of the shipped service, may inhibit the rise in freight rates.	Finke and Kotzab (2017), Fung et al.(2003), Grama (2014), Malchow and Kanafani (2004), Notteboom and Rodrigue (2008), Sahin et al. (2007), Stopford (2009)
Route	Freight may vary with departure and destination sites, and with the route followed.	Malchow and Kanafani (2004), Ballou (2004), Banomyong (2005), Bowersox et al. (2014), Hesse and Rodrigue (2004),
Economic situation of countries	Higher rates are charged in emerging economies, compared to developed countries, resulting in lower business volumes and revenues.	Hummels, Lugovskyy and Skiba (2008), Jacks and Pendakur (2010), Lee and Lee (2012), Murray (1996)
Possibility to return cargoes	The freight involves not only shipping costs, but also the shipping options available in the departure site and the possibility to return the cargo to the departure point.	Finke and Kotzab (2017), Grama (2014), Notteboom and Rodrigue (2008)
Bunker Adjustment Factor (BAF), additional fee for fuel.	Shipowners see fuel consumption as one of the main factors, since lasting oscillation in crude oil prices interferes directly in shipping.	Maloni et al. (2013), Notteboom and Cariou (2013), Notteboom and Rodrigue (2008)
Competition	Shipowners that do not face competition in determined route charge higher freight rates.	Ho et al. (2017), Hummels et al. (2008), Notteboom and Rodrigue (2008), Sahin et al. (2007)
Vessel capacity	Freight is affected by the relationship between ship capacity and demand.	Leach (2014), Notteboom and Cariou (2013), Stopford (2009)

RESEARCH DESIGN

The variables that influence ocean freight rate oscillation in Brazilian trade to the USA, Europe and China were analyzed using a qualitative approach due to the need of a wide and in-depth perspective of the study problem and the nature of the issue (Creswell, 1998). A qualitative study also enables greater flexibility, since several aspects associated with the fact or with the phenomenon under investigation are considered.

The research design for this study was divided in four steps, according to Figure 1. The first step started with the literature review, when, at the end, 12 variables responsible for oscillations in international freight rates were identified, according to Exhibition 1. Based on the 12 variables identified, a panel of experts was assembled, formed by managers responsible for pricing ocean freight rates in Brazil in their companies. The panel was arranged in order to obtain confirmation of the effect of the 12 variables on freight rates as well as to understand the relationships among those variables and between these and ocean freight.

Figure 1. Methodological steps



(1) First round of interviews.
(2) Second round of interviews.

Consulting other people's opinions has been commonly used as a strategy in the decisions involving themes surrounded with great responsibilities in terms of results or controversial subjects that entangle quite complex variables that lead to uncertainties as to the possible results (Yaniv, 2004). According to Budescu and Rantilla (2000), expert panels are recommended when (i) there is a need to make a decision in the short term, (ii) the possible results are surrounded with uncertainties, (iii) relevant information that may mitigate uncertainties is available, and (iv) it is possible to confer with experienced professionals who have relevant information.

To select the right specialists to perform an expert panel it is recommended a group of, at least, six judges with large experience on the subject to be discussed, according to Yaniv (2004). In this sense, the 13 most representative shipowners around the globe (Alphaliner Top 100, 2016), with operations in Brazil, were invited personally and by phone to become part of the panel. At the end of this phase, five shipowner representatives in Brazil agreed to participate in the panel.

In order to add different perspectives regarding freight rates, the researchers asked the five specialists to indicate freight forwarders and co-loaders that also offered maritime freight in Brazil. The five specialists indicated the same freight forwarder, classified as the 7th largest company in the segment, according Armstrong & Associates (2015), and one co-loader with consistent Brazilian market share. After a phone invitation, these two firms accepted to join de panel, as described in Exhibition 2.

In the second step, a first round of in-depth interviews with the seven experts was conducted. The third step consisted of the content analysis to assess the data as a means to understand the behavior of the variables pointed in Exhibition 1 and that influence ocean freight rates of containerized dry cargoes for Brazilian trade with the USA, Europe and China. For Bardin (1977), this analytical technique comprises three stages: (i) pre-analysis, (ii) exploitation of the material, and (iii) treatment and interpretation of results. Here, content analysis was chosen since, according to Kolbe and Burnet (1991), it is an observational research method that is used to systematically evaluate the symbolic content of all forms of recorded communications. To accomplish that, the analysis categories were restricted to the 12 variables identified previously in Exhibition 1.

After the content analysis of the first round of in-depth interviews (Exhibitions 3 and 4), the authors developed a table with the behavior of twelve variables listed in the context of Brazilian ocean freight, in order to capture the relationship among them. So, in the fourth step the relationship table was presented again to the same panel in a second round

of in-depth interviews with the aim of obtaining a consensus (Budescu & Rantilla, 2000) regarding the association between variables and international ocean freight (Exhibition 5).

DATA ANALYSIS

In the first round of interviews with the panel of experts, the 12 variables identified in the literature review (Exhibition 1) were presented to the panel, who evaluated the importance of each in international ocean freight pricing. The panel ascribed a score to variables in a 0 – 5 scale, in which 0 denotes the absence of any influence in pricing, while 5 indicates a strong effect on the definition of freight rates. Therefore, according to the panel, the variables *supply and demand* and *vessel capacity*, both with score 4.71, had the strongest influence on freight pricing. On the other hand, the variables *distance sailed* by vessels and *economic situation of countries* involved in the importation/exportation business, both with 2.57, were the ones with the lowest score, showing that they were the ones that least influence freight pricing.

After that, the experts were invited to talk about the variables that influence de freight oscillation and the possible explanations for those evidences. The Specialist E1 declared that "shipowners are increasingly looking for financial return in order to recover losses in previous years, though freight rates are consistently observed to fall in some trades".

To identify the cutoff value in the time series, four interviewees declared that a 3-year survey about trends in the markets involved in these trades would suffice. However, specialist E6 warned that:

When it comes to China imports, even a 10-year time series of freight rates would not afford to understand the reasons behind such oscillations, let alone predict freight rates in the next five years. For Europe, two years are enough to see that the market is stable, which allows for more assertive predictions.

In this sense, the authors decided to separate the analysis into two sets of trades: Brazilian freight rates with the USA and Europe trade, which represents a trade with more stable freight rates; and Brazilian freight rates with China trade.

Variables affecting freight in Brazilian, USA East Coast and Northern Europe trade

The freight rates charged by four global shipowners (all of whom are European) for trade with the USA East Coast were analyzed by the experts considering the New York port, which is the busiest one in terms of twenty equivalent unit (TEU) container flow in the region. According to the specialists, these rates were considered relatively low and could pose a risk to the financial health of shipowners operating in this trade route (Jacks & Pendakur, 2010).

The data analysis revealed that ocean freight rates in this trade also decreased in the recent years. According to the experts, this trade route exhibited a stabilization trend with minor pricing changes, though rates decreased consistently for a long period of time. The average freight of all kind (FAK) rate was about USD 1800 in 2012 and fell to USD1000 in 2014, pointing to a decrease in annual mean values. According to the specialists, this scenario may induce players to cease to offer freight services to the USA east coast, due to the low demand and freight rates, which makes business less attractive to most shipowners.

On the other hand, the freight rates were evaluated for a northern Europe trade route considering the Brazilian port of Santos and the Rotterdam, Hamburg, and Antwerp ports. The same process was carried out for freights between these European ports and Brazil. Three European and one Asian shipowners were considered, all of whom provide freight services based on their own ships. The average FAK in this route has been falling on a yearly basis. The freight rates exhibited a trend towards stabilization, despite the rises and drops observed at times, according to the experts.

To understand the trend exhibited by shipowners towards maintaining international freight rates within a safety net in these two trade routes (northern Europe and USA east coast), the specialists were inquired over the variables that helped to maintain these rates essentially free of oscillations. The answers provided point to an interaction between these variables, which afforded to analyze them separately and then establish a link between them and the other answers. Exhibition 3 presents the variables that helped maintain the stability in freight rates, as listed by the participant experts.

Exhibition 2. The panel of experts

Expert interviewed	Firm Position	Years in ocean freight	Firm Type	Firm's Country of origin	Year of foundation
E1	Regional Manager	14	Freight Forwarder	USA	1979
E2	Pricing Manager	8	Shipowner	Germany	1970
E3	Pricing Manager	18	Co-loader	Brazil	1994
E4	Global Account Manager	18	Shipowner	Denmark	1904
E5	Pricing Manager	17	Shipowner	Canada	1993
E6	Commercial Manager	35	Shipowner	Chile	1970
E7	Traffic Manager	6	Shipowner	France	1978

Specialist E1 added:

> *No considerable change in demand and supply issues were recorded in these markets... the services provided by shipowners during the period did not change as in other trade routes, like the China trade route, for instance... in addition, I think that the kind of goods shipped in these markets reduces the variation in freight rates.*

The answers obtained allowed for the identification of some relationships between variables, such as predicting the markets where no change in the services offered will take place induces shipowners to maintain freight rates. In a similar way, the capacity of vessels, when adjusted for the demand, has the same effect for a 1-year period. Moreover, since the countries where the ports considered enjoy a level of economic activity, it is presumed that freight rates will remain essentially constant and within a safety margin, similarly to the other figures.

Variables affecting freight in Brazilian and China trade

The FAK rates applied by six shipowners (three Asian, three European) offering their own services and vessels in the China trade route to Brazil were evaluated by the specialists for a period of five recent years. The results indicated that FAK rates remained constant for more than 30 days, when importation from China is analyzed. Freight rate in this route in 2012 was USD1822 by TEU, and fell to USD1229 in 2013 and to USD1070 in 2014.

The content analysis of the questions addressed to the panel of experts showed that several variables influence freight rates for China trade with Brazil, according to Exhibition 4. The variable about the supply capacity and the market demand for international ocean transportation was mentioned by all specialists, though other variables were also mentioned as playing a role in the variations observed.

Exhibition 3. Variables influencing freight rates in Brazil, Europe and the USA trade

Europe and USA	E1	Supply and demand; Commodity; operational costs.
	E2	Vessel capacity; Cargo weight and volume; Competition.
	E3	Supply and demand; Vessel capacity; Competition.
	E4	Supply and demand; Vessel capacity; Competition.
	E5	Supply and demand; Vessel capacity.
	E6	Supply and demand; Vessel capacity; Return cargo.
	E7	Economic situation; Commodity; Supply and demand.

The analysis also revealed that the variables listed by specialists as responsible for the persistent oscillations in containerized dry cargo ocean freight rates in the China trade route are exactly the same as those that explain the relatively constant values on a yearly basis in the east USA coast and northern Europe routes, as shown in the previous section. In addition, it should be highlighted that the specialists pointed out the trend in large shipowners to form new partnerships. This would eventually add to the stability in the ocean freight rates, since they would become more profitable for freight companies, which could charge higher rates as compared to those reported in the present study.

Proposal of a causal relationship among individual variables

One of the objectives of this study was to understand the dynamics among the variables that influence ocean freight rate of Brazilian trade with the USA, Europe and China. Therefore, the set of data offered by the specialists in the first round of in-depth interviews were combined with the objective of proposing a set of causal relations for future quantitative analysis to validate its effects. However, some studies already explain the behavior of many variables in terms of ocean freight rates, which helped to a better understanding. (Ballou, 2004; Bowersox et al., 2014; Grama, 2014; Ortúzar & Willumsen, 1994; Stopford, 1997; Florentino, 2010).

Therefore, Exhibition 5 shows the proposal of a causal relationship among individual variables related to Brazilian freight rates of trade to the USA, Europe and China and how theses variables affect ocean freight rates. As observed, the variables *commodity, cargo weight,* and *number of containers* were classified as direct variables in the context of ocean freight rates, since any increase or decrease in the values representing these variables elicit oscillations in ocean freight rates, according to the specialists.

Exhibition 4. Variables influencing freight rates in Brazil and China trade

China	E1	Operational Costs; Supply and demand; Vessel capacity.
	E2	Supply and demand; Vessel capacity.
	E3	Economic situation; Supply and demand.
	E4	Supply and demand; Vessel capacity; Economic situation.
	E5	Supply and demand; Vessel capacity.
	E6	Competition; Vessel capacity; Supply and demand.
	E7	No opinion.

Exhibition 5. Proposal of a causal relationship in Brazilian freight based on experts' opinion

Variables	Relations among variables	Proposal of causal relations
Commodity (Com)	The higher the commodity value, the higher the freight value	+ Com ➔ + OFrg
Cargo Weight (CgW)	The heavier the container, the higher the freight.	+ CgW ➔ + OFrg
Number of Containers (NoC)	The higher the number of containers shipped, the lower the freight by container.	+ NoC ➔ (-) OFrg
Ocean Freight (OFrg)	The lower the ocean freight, the higher the demand.	(-) OFrg ➔ + Dem ➔ + Sup ➔ ➔ + Comp ➔ (-) OFrg
Demand (Dem)	The higher the demand for ocean freight, the higher the supply of ocean freight.	
Supply (Sup)	The higher the supply, the higher the competition.	
Competition (Comp)	The higher the competition, the lower the freight value.	

Supply (Sup)	The higher the supply, the higher the capacity of the vessel.	+ Sup ➔ + CoV ➔ + Fl ➔ + OpC ➔ ➔ + OFrg
Capacity of the Vessel (CoV)	The higher the capacity of the vessel, the higher the fuel consumption.	
Fuel (Fl)	The higher the fuel consumption, the higher the operating costs.	
Operational Costs (OpC)	The higher the operational costs, the higher the freight value.	
Economic Situation (EcSit)	The lower the business volume, the lower the possibility of return cargo.	(-) EcSit ➔ (-) RetCg ➔ + Frg
Return Cargo (RetCg)	The lower the return cargo, the higher the freight value.	

To endorse the relationships presented in Exhibition 5, a second round of in-depth interviews was carried out to validate and to obtain a consensus in the panel of experts regarding the relationships observed among the variables listed.

Considering the variable *commodity*, five of the seven specialists agreed that the higher the value of the goods, the higher the freight charged will be. However, specialist 4 warns that "yes, it is considered so, but it is not the most important, since, for example, the rate charged for wood is the lowest in the market, compared with auto parts or medical drugs, which are higher".

Specialist 2 confirms this notion, though in a more objective way, saying that "a more expensive product costs more and, therefore, freight should also be charged at higher rates". Thus, in spite of the fact that most specialists agree on the relationship between *commodity* and ocean freight rate, some studies did not take it into consideration when pricing ocean freights (Bowersox et al. 2014; Ortúzar & Willumsen, 1994). On the other hand, other studies pointed at the same direction as the specialists, stating that the cargo value impacts on freight rate due the risk of damage (Grama, 2014; Zeng & Rossetti, 2003).

The variable *weight/volume* is directly related with ocean freight rate, since, according to the specialists, the greater the weight, the higher the rate. Six of the seven specialists agree on the relationship between cargo weight and ocean freight rate, consistent with Maloni et al. (2013), Bowersox et al. (2014), and Notteboom and Rodrigue (2008). For example, specialist 1 declares that "as a rule, this practice is used in the market. However, overweight surcharge is applied for loads in excess of 20 tons, and lighter cargoes admit better negotiation bargains".

Similarly, specialist 3 believes that "ocean freight companies usually define a maximum weight acceptable for transportation, considering the freight rate informed. When the container's weight exceeds this value, an additional fare is charged as overweight. It is a means to charge more for heavy equipment". Specialist 7 states that "cargo weight, many times, influences freight rate, since the heavier the cargo, the more difficult to fill TEU slots in the vessel".

The variable *number of containers* is interpreted in terms of the cargo volume to be shipped, since specialists declare that the larger the number of containers regularly shipped, the lower the ocean freight rate charged. This point was consistent with de findings of Maloni et al. (2013) and Notteboom and Rodrigue (2008). The seven specialists agreed that this variable is directly correlated with rates. As specialist 7 puts it:

When the customer has a larger cargo to ship, we may negotiate a lower rate. We are always interested in filling up the slots in vessels. Larger cargoes allow to fill slots more easily than one or two containers per client only.

Specialist 3 adds that:

> *This happens for some contracts only. It is always possible to obtain better rates when the volume being negotiated is large. Yet, when the demand for transportation in a route is too high, the trend observed is usually the other way round, due to the limitation in shipping capacity of vessels. Full vessels imply higher rates.*

During the second round of results validation, based on the answers given by the specialists in first round of interviews (Exhibitions 3 and 4), some different statements were produced. The last

round showed that the lower the ocean freight, the higher the demand for international transportation services. Therefore, shipowners attempt to increase the available space in vessels and, as a result, new players make extra efforts to enter this market. As a result, with increasing competition, the trend would be towards lower rates (Tang & Sun, 2018).

The specialists reached a consensus on these relationships, though they brought a better explanation on the relationships that actually influence Brazilian ocean freight rates. Specialist 3 agrees on the relationship between these two variables, but adds that:

> *The entry of new competitors in a promising ocean route induces a drop or the stabilization of rates. However, the cargo should be such as to afford to appropriately fill the slots in vessels, since shipowners tend to reduce the supply of space in order to avoid losses when this supply is high and the volume to be shipped is not high enough. It should be remembered that low freight rates are not the main factor to attract more business or demand for ocean transportation (E3).*

Specialist 7 agrees with the declaration above, and offered a more in-depth analysis of these variables:

> *The lower the ocean freight rate, the more companies feel encouraged to export, increasing demand, since transportation costs strongly influence the end cost of any operation in international trade. In a scenario of low rates, the main players will compete for cargoes, which will eliminate market space. As a result, freight rates rise again. Under low rates, there will always be players that can't follow the trend, which increases space. When rates are too low, new players may enter the market, as long as they manage to offer good service at the same freight rates as charged by the main competitors. Many times, smaller players can't proceed, due to the operational costs of the services they offer. But when they manage to, competition increases, which may promote a drop in freight rates, since there will be more options (E7).*

However, specialist 6 disagreed with some relationships, and explained the reasons:

> *Demand for international transportation services should not be subject to oscillations due to high or low freight rates. There are other reasons, of socio-economic character, at a given time. Freight varies, as a rule, due to the unused capacity in vessels. This implies considering the entry of new players in trade routes (E6).*

Specialist 4 agrees with specialist 6, and adds:

> *If a specific service or route operates under low freight rates, shipowners do not underscore the supply of shipping space or even vessels, but the capacity is adjusted to the actual demand. Therefore, new players will hardly be able to enter this market, unless it is profitable (E6).*

In this sense, some specialists argued that the low ocean freight rate boosts the demand for ocean transportation services, since it is directly correlated with competitiveness of exporter companies in the destination market (Notteboom & Rodrigue, 2008). Nevertheless, other specialists believe that the demand for ocean transportation services is not affected by freight rates. Therefore, the opposing views were analyzed in terms of the variables *supply* and *demand*, which, according to the specialists, is the main relationship to influence international ocean freight rates.

As for competition, all specialists mentioned the constant efforts of shipowners to adapt the available space in vessels to the actual demand. Yet, new players are more inclined to start operations in trade routes where freight rates are not too low, or when a route shows good business opportunities. Shipowners are not interested in entering markets where slot availability exceeds the demand. In spite of that, the specialists agree that increased competition may lead to a decrease in ocean freight rates, consistent with the findings of Grama (2014), Maloni et al. (2013), and Hesse and Rodrigue (2004).

The second round of the variables validation showed the lower the ocean freight rate, the higher the demand for associated services. In this sense, shipowners would be inclined to increase the space available in vessels. If one takes into consideration that supply and demand would trigger the flow of goods, the commercial status of countries with a role in exportation and importation markets would reach a level of stability, which would reduce the need for replacing containers in the country of origin and, for this reason, the trend would be towards increasing ocean freight rates.

The specialists analyzed the relationships between *ocean freight rate*, *demand*, *supply*, *economic situation*, and *return cargoes* in order to produce a clear picture of the contribution of each in the oscillation of

ocean freight rates. One specialist clarified the issue very objectively:

> *With increased demands, the flow of goods tends to rise. This may reduce the need for repositioning containers, both in the origin and in the destination countries. This alone does not lead to higher freight rates, though it may raise profit contribution each shipment generates to the carrier. It may be necessary to increase rates when there is a lack of equipment in the departure port and an excess of equipment in the destination port (E4).*

Nevertheless, the specialists disagree on the relationships in which the increase in the demand for international transportation services and the increased supply of vessels directly contribute to the improvement in the commercial relationship between the countries involved in the operation. On the other hand, a consensus was reached on the fact that the improvement in commercial situation of countries increases the chances for containers not to be repositioned in the destination, which means a greater advantage to the shipowner, since it will not be necessary to charge a low freight rate (Fung et al, 2003).

In the analysis of the relationships involving the variables *ocean freight rate*, *demand*, *supply*, *vessel capacity*, *fuel*, and *operational costs*, the specialists explained their views about the pricing of ocean freight rates. Exhibition 5 shows that the lower the freight the higher the demand for international transportation services. So, shipowners would try to increase available space in the long run based on vessel capacity. Therefore, the costs associated with fuel in larger ships would also be expected to rise, increasing the operational costs of vessels. As a result, the final freight rate would be down against the unit cost to ship one container.

Specialist 7 agrees, and warns:

> *Larger vessels imply higher operational costs, though once they can carry larger numbers of units, this cost spreads across this extra volume. The freight rate is not necessarily reduced due to operational costs. However, large vessels require greater cargoes in order to fill up all slots. This need for more cargo is the factor that makes rates drop (E7).*

Although large ships are designed to consume less fuel and therefore be more advantageous economically, they require greater effectiveness in the allocation of slots by shipowners (Fung et al., 2003; Maloni et al., 2013). Therefore, by increasing capacity, shipowners need greater cargoes in order to load a ship to the full and split the high fuel and operational costs across the thousands of units on board.

According to the specialists interviewed, the trend for the years ahead is towards a readjustment in vessel capacity in trade routes in which ship occupation rates are below 70%, depending on the time of year, as observed in the trade routes with China. Concerning market stability and freight rates, specialist 6 does not envisage a real market stability, not until 2018, exactly due to the increase in ship size and in slot availability. In addition, for specialist 6, the balance between market demand and supplied capacity would be reached if shipowners stopped ordering new ships. However, orders for new ships and requests for increasingly larger ships are quite common today. This is disadvantageous to Brazil, since the port infrastructure is not fit to receive large ships, due to the large load-draught of these vessels and the logistic problems in the port and adjacent area.

At the same time, Brazil presents a delicate freight situation regarding its small share in worldwide trade. According to MDIC (2017), Brazil counts for about 1% of the total of international trade and any exchange rate fluctuation increases or decreases the imports or exports, but not in the same way. So, as the transportation costs of an empty container are similar to the costs of a loaded one (Finke & Kotzab, 2017), when Brazilian imports decrease, replacing the empty containers for Brazil results in additional costs and impacts on freight oscillation (Lee & Lee, 2012).

IMPLICATIONS AND FINAL CONSIDERATIONS

In a scenario of constant debate among Brazilian exporters and importers regarding the variables that influence freight rates, this study aimed not only to identify the variables involved on this matter, but also to characterize the relationships between these variables and freight rates in Brazilian trade to the USA, Europe and China. The final goal was also to help build a future tool that can predict oscillations or confirm the conservation of freight rates for the following period of shipments in Brazil.

A literature review of international databases of papers published in the past 20 years was conducted in this study (Exhibition 1) to identify the variables

that, at least in theory, affect ocean freight rates. That research indicated 12 variables that influence the ocean freight rates. These variables were discussed in qualitative interviews with a panel of experts. It was found that some of these variables do not explain directly the oscillations in freight rates in Brazilian trade with the USA, Europe and China. That was the case of the variables *distance sailed* by the vessel and possibility of *return cargoes*. These aspects could be explained by the nature of the Brazilian international trade that is based on commodities like iron ore, soy, coffee, and sugar in exports (MDIC, 2017) and don't need containers for transportation. On the other hand, there are more cargoes that need containers for Brazilian imports. The distance sailed was studied and could affect more freight for commodities as wheat (Binkley & Harrer, 1981).

Perhaps the same explanation could provide the reason of the variable *economic situation* of countries, which was cited by the specialists as one of the factors that less influence Brazilian ocean freight rates. It means that international commodities, the common goods exported by Brazil (MDIC, 2017), actually don't need containers. So, theoretically, one could argue that, given the lowest score, the variables *distance sailed* by the vessel, possibility of *return cargoes* and the *economic situation* of countries are suppressed or adjusted by the supply and demand of maritime transportation, as well as by the value of the goods transported.

Based on the experts' opinion, it was possible to observe that all relations presented in Exhibition 5 are capable of producing effect on Brazilian freight rates. However, although the variables discovered to influence the ocean freight rates charged in China trade route with Brazil are the same as those that affect rates in the USA and Europe trade with Brazil, a relationship observed can act in different manners in those two trades. For instance, during the two rounds of interviews, the specialists constantly underlined the stability between demand and supply as the main aspect to affect freight rates. When the demand for ocean transportation stabilizes within acceptable levels, considering the containers capacity made available by shipowners, the freight rates will eventually remain constant.

Nevertheless, in times when the demand for international transportation services increases, other different issues must be considered to influence freight rates, according to the specialists. These new set of variables can be the free slots available in vessels and new ships with higher capacity offered in the trade route. It could provoke lower freight rates charged in the market, and, therefore, and stimulate the demand for these services.

The results of the present study pointed to the need for further investigations using a quantitative approach to prove the statistical value of these variables in terms of ocean freight rates using correlation and regression tests, for instance. In addition, some Brazilian specific conditions such as exchange rate, based on the time series of freight rates, could help build a systemic modeling considering all variables associated with ocean freight rates. This would enable the prediction of oscillations in rates based mainly on the fluctuations in the variables listed.

In this same sense, this paper did not discuss the effect of the type of maritime freight service that can be provided by freight forwarders (OFFs) or by container shipping lines (CSLs) directly. Ho et al. (2017) found some differences in pricing and conditions for using one of those type o firms. Studies that could isolate the influence of the type of service offered in the formation of Brazilian maritime freight would be fruitful.

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ARTICLES

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SUSTAINABLE PRACTICES IN THE COFFEE SUPPLY CHAIN IN THE CERRADO MINEIRO REGION, BRAZIL

ABSTRACT

The incorporation of sustainable practices in the supply chain management (SCM) has become recurrent in the business environment, resulting from a social reflection on the need to seek new development alternatives. In this context, the objective of this paper is to verify the existence of sustainable practices throughout the supply chain of coffee in the Cerrado Mineiro Region (CMR) and to understand the effects of this adoption regarding Green SCM. This paper focus on the relationship between producers and collective organizations, such as cooperatives and development foundations. To this end, a case study was carried out with the representatives of the supply chain members in CMR, which included coffee producers, cooperatives and a development foundation. It was verified the predominance of practices focused on environmental issues, followed by social and, finally, economic ones. It is also highlighted that the data identified allow us to understand that the development of sustainable strategies can bring positive effects to the agents studied. Considering that these aspects, evidently, improve the relationship of supply chain members, making it more collaborative. The results contribute to the systemic understanding of the way in which sustainability has been incorporated and operationalized in coffe supply chains in CMR.

KEYWORDS | Cerrado mineiro region, green supply chain management, sustainability, supply chain management, sustainable practices.

Warley Henrique da Silva
warleyhsunai@gmail.com

Patrícia Guarnieri
patguarnieri@gmail.com

José Márcio Carvalho
jmcarvalho1708@gmail.com

Universidade de Brasília, Faculdade de Administração, Contabilidade, Economia e Gestão de Políticas Públicas, Programa de Pós-Graduação em Agronegócios, Brasília, DF, Brazil

INTRODUCTION

The depletion of patterns of development experienced since the twentieth century is evident. The understanding of this phenomenon, together with social reflection on the need to seek new alternatives for progress, has given rise to a new development model. The sustainable development model, which has been consolidating since 1972, the year in which the discussion of this issue, during the First Conference on Environment and Development held in Oslo, Norway.

In their investigations, Mathiyazhagan, Govindan, and Noorul Haq (2014) recognize that organizations in the most diverse economic sectors face pressures from public authorities, competitors and, above all, the consumer market to incorporate sustainable correct practices in their supply chains. This adoption occurs in order to minimize damage to the environment and society. This context, refers to the ideas of Elkington (1994), when the author deals with the Triple Bottom Line (TBL).

In addition, Food Supply Chains are not excluded from this process. Although in a timid way, it is noticed that the food sector has been following the changes in the consumption pattern of the society, in which a trend is evident on the part of the consumers as to the option for foods obtained from production systems that adopt environmentally correct and socially just practices in their productive processes. The focus on SCM is an important step in the adoption and development of sustainability, and the concept of Sustainable Supply Chain Management ((SSCM) directs efforts in this perspective. However, Mathiyazhagan et al. (2014) recognize that the incorporation of sustainable aspects into supply chains is a practice still uncommon in most organizations, especially in countries from emerging economies.

Jakhar (2015) highlights that research must aim to encompass all the sustainable development dimensions advocated by Elkington (1994), ie, economic, environmental and social, in order to have an holistic approach to supply chain sustainability and an understanding of the mechanisms involved in the sustainable product supply. The studies from Fabbe-Costes, Roussat, and Colin (2011), Bask, Halme, Kallio, and Kuula (2013), Brandenburg et al. (2014), Su et al. (2016), Kumar and Rahman (2016), and Alshubiri and Hussein (2016) encompassed all dimensions of Sustainable development in supply chain management. Nevertheless, these studies were developed in a small variety of supply chain, with emphasis on the automotive industry, retail trade and metallurgical industry.

We have identified few studies with a holistic approach to sustainability in food supply chains, mentioning the studies of Walker and Jones (2012) and Türkay and Saraçoglu (2015), which were applied in agrifood supply chain in the United Kingdom and of Turkey, respectively. In addition, it can be seen that a considerable amount of studies directs its analysis to the final links of the supply chain, that is, in the distribution/consumption interface. In this sense, the studies from Carvalho, Paiva, and Vieira (2016), Migliore, Schifani, and Cembalo (2015) and Krystallis, Chryssochoidis and Scholderer (2007) should be highlighted.

The present study was developed at the production/processing interface, that is, at the initial links of the supply chain, comprising coffee producers, their cooperatives and development organizations. The focus is on Cerrado Mineiro Region, which is considered one of the main coffee producing territoriesin Brazil. It is the first region to produce coffee demarcated in the country, according to a decree of the Minas Gerais government, Brazil, since April 1995.

In this context, this paper aims to verify the existence of sustainable practices along the supply chain of coffees in Cerrado Mineiro Region and to understand the effects of this adoption with regard to the Green SCM focusing on the relationship between producers and collective organizations, such as cooperatives and foundations of development.

In order to attain this objective, it was conducted na applied research, with qualitative approach. A case study in Cerrado Mineiro Region was carried out in order to collect data through questionnaires and semi-structured interviews with the representatives of the coffee supply chain links. The research involved coffee producers, cooperatives and a development foundation. In a complementary manner, it was also conducted a documentary analysis based on reports provided by the aforementioned supply chain members.

This paper aims to broaden the discussion of the sustainability in coffe supply chains, by proposing an analysis of the existence of sustainable practices and a subsequent explanation of the effects of these in Cerrado Mineiro Region, Brazil. Besides that, this paper contributes for the academic literature by

identifying a research gap, considering that the recent researches have still not enough discussed on the dynamics of supply chains in the food sector, specifically in the case of coffee, from the perspective of the three sustainable development dimensions proposed by Elkington (1994). Regarding the managerial practice contributions, the analysis proposed in this study may favor the decision-making process by the agents that operate in the coffee supply chain, mainly in the case of producers, cooperatives and development foundations.

In addition to this introduction, the paper presents four other sections. In the first one, the theoretical basis under which the article is developed, which includes issues related to sustainability and the Green SCM, is presented. The second section presents and justifies the methodological procedures adopted in this research. In the third section, the results are presented and discussed later in the light of the theory. In the fourth and last section, the final considerations of the article are presented.

LITERATURE REVIEW

Supply chain: management and sustainability

One of the main definitions adopted in the literature for the term supply chain was disseminated by Mentzer et al. (2001). According these authors, this is a set of three or more companies directly involved in the upstream and downstream flow of goods, services, financial resources and information from the beginning of the chain to the end customer. In this context, Guarnieri and de Almeida (2016) recognize that for the existence of a supply chain, it is necessary to understand that customer satisfaction is the essential component. A supply chainstarts when the customer orders a product or service and ends when the payment is made.

Aligned with the understanding that a supply chain brings together a number of internal and external business processes of the business environment, it is essential to comprehend the fundamentals of SCM. One of the main definitions for the term was proposed by Mentzer et al. (2001), in which the authors state that SCM is a management model integrating the (systemic and strategic) traditional business functions within a particular company within supply chain, for the purpose of achieving long-term improvement.

The SCM concept has been recognized as a key factor in promoting organizational sustainability. In this sense, Stonebraker and Afifi (2004) emphasize that the success of a supply chain depends on management's ability to recognize changes in the corporate environment. In addition, Carter and Rogers (2008) define Green SCM as the strategic and transparent integration of social, environmental and economic aspects in the systemic coordination of organizational processes with a view to improving the long-term economic performance of the company and its supply chain. Carter and Liane Easton (2011) state that Green SCM is related to long-term improvement and has significant implications for the economic results of companies.

In other words, the Green SCM is defined as the management of material, information and capital flows, as well as cooperation between companies throughout the supply chain, while adopting sustainable development goals, i.e., the integration of the environmental, social and economic dimensions (Seuring & Müller, 2008). In order to meet the needs of stakeholders, according Ahi and Searcy (2013), the Green SCM consists of the creation of supply chain coordinated through the voluntary integration of economic, environmental and social policies with the interorganizational business systems designed to efficiently manage diverse processes of the company. This management constitutes a way to extend the profitability of the business, in addition to providing greater competitiveness and adaptability in the short, medium and long-term.

Regarding agri-food supply chains, which may include dairy products, grains, vegetables, meats, flowers and fruits, Routroy and Behera (2017) conceptualize that these are initiated from relationships with suppliers (i.e., materials and services of entry for farm-level operations) and are finalized through customer satisfaction through a specific distribution channel. Also in this context, Rais and Sheoran (2015) identified some factors that affect the performance of agri-food supply chains, such as cold storage unavailability, lack of government policies, inadequate connectivity, classification unavailability and classification technology, inadequate handling and packaging, unskilled labor, poor articulation in marketing, and other.

Clemens and Douglas (2006) state that some companies consider that adopting supply chain sustainability creates a commercial and competitive advantage.

Wang, Teng, and Lou (2014) understand Green SCM as a business strategy aimed at minimizing the environmental, economic and social risks of the organization to create corporate value.

Thus, Bask et al. (2013) point out that companies that adopt Green SCMrecognize that social and environmental impacts need to be managed in the same way as financial and commercial performance. They also suggest that in order to be competitive and survive in the market, especially in the coming decades, companies need to extend their sustainable practices throughout the supply chain. Therefore, companies need to foster their sustainability efforts beyond their own operations, including the practices of their suppliers and the satisfaction of their customers' sustainable expectations (Porter & Kramer, 2006).

In Koberg and Longoni's point of view (2018) sustainable supply chain management has been suggested to improve business sustainability results. Nevertheless, the authors acknowledge that this management model implies unique challenges as adopted in global supply chains, such as coffee. It is understood that such challenges advocated by Koberg and Longoni (2018) may be related to the configuration of the global supply chains, since the connections between the focal company and the various suppliers and customers, including the sub-layers, may be hampered by geographical issues and culture.

In relation to food supply chains, Wu and Huang (2018) reveal eight crucial characteristics for the success of adopting sustainability in supply chains: (1) the use of management software; (2) eco-innovation; (3) organizational culture; (4) storage capacity; (5) transportation options; (6) reduction of losses and waste; (7) availability of physical resources and; (8) regulatory frameworks. Among them, Wu and Huang (2018) highlight the two most important factors for the successful implementation of sustainability, being eco-innovation and reducing food loss and waste. These characteristics, which can also be understood as challenges for the management of supply chains, have reoriented business relationships within the agri-food sector (Cembalo, 2015, Wu & Huang, 2018).

METHODOLOGICAL PROCEDURES

Regarding to the methodological procedures used in this study, a case study was first developed with coffee producers, cooperatives and the Cerrado Mineiro Development Foundation (Fundaccer). The data collectiion was based on the following research instruments: (1) Questionnaire applied to coffee producers included in the Cerrado Mineiro Region, Brazil; (2) Semi-structured interview script, conducted with the managers of the cooperatives to which these producers were associated and of Fundaccer (development foundation); (3) Direct non-participant observation, as well as videos and photos, both in relation to the coffee production process, as well as the inherent aspects of the relationship between producers, cooperatives and Fundaccer e; (4) Documentary analysis (Development Plan, Sustainability and Promotion of Cerrado Mineiro Region, Brazil 2015/2020, among others).

The research with coffee producers was developed with the aid of a structured questionnaire, which was adapted froma validated scale proposed by Zhang, Tse, Doherty and Akhtar (2018). Considering the adaptation of the questionnaire, it was sent to the validation of content by judges (professionals of the coffee industry and researchers in the area). After this evaluation, it was verified that the adaptation was coherent and, then, it was done with the re-construction of this instrument. For the measurement of variables, a Likert-type scale was adopted. It is a non-comparative scale, of the itemized type, in which the participant points out a single item, according to their degree of agreement (Malhotra, 2006). Due to the context of this study, we chose to use the Likert scale with five levels (1-5), considerint the 1 the lowest level and the 5 the highest level of concordance.

Data collection from cooperative managers and Fundaccer was carried out through interviews, conducted face-to-face and via Skype. In order to operationalize the method, a semi-structured script was used, which was also elaborated based on the scale proposed by Zhang, Tse, Doherty, and Akhtar, (2018), in order to triangulate the results of the questionnaires with the coffee producers and interviews conducted with managers. During the interviews with the managers, who had already been previously scheduled through e-mails and telephone calls, voice recorders were used, with the permission of the interviewees. The use of this instrument made it possible later that such interviews were transcribed and sent in a text file in order to be validated by them. So the participants of the interview could confirm or refute what they had said at the time of the interview. It should be noted that parts were complemented in this process.

The choice of the participants in the Fundaccer considered the criterion of representativeness, considering that managers interviewedhad information regarding the sustainable management of the supply chain. Two (2) collaborators of the organization were interviewed, who work in sectors directly linked to coffee producers. Regarding the choice of coffee producers, in the first moment, it was defined by convenience and accessibility. In a second moment we adopted the methodological technique of Snowball.

Sampling

Baldin and Munhoz (2011) point out that the Snowball technique is widely used in the social sciences mainly in qualitative research. In this techniquethe initial participants of the study indicate new participants who, in turn, indicate others and so, successively. It is indicated for identify study participants who are often geographically dispersed.

Regarding the representatives of the cooperatives, only managers who participated actively in the activities related to coffee, thecriterion adopted was also representativeness. Thus, the participants were selected considering the position they have within the cooperatives. It was decided to hide the names of cooperatives, considering that one of these organizations requested that its name not be mentioned. Thus, for purposes of standardization and guarantee of secrecy of information, cooperatives are identified by (1) Cooperativa Alfa; (2) Cooperative Beta and; (3) Cooperativa Gama.

For the analysis and treatment of data, it was used the Content Analysis method, proposed by Bardin (1977). The content analysis was operationalized through the data collected in the interviews, both with producers and managers of the cooperatives, besides those from the systematic reviews. The logic of applying this method of analysis consists on the importance of establishing categories of analysis for the data collected, which are essentially qualitative in nature. Post-categorization was adopted, according to Bardin (1977). The categories were defined a priori based on the article by Zhang, Tse, Doherty and Akhtar (2018) and also adapted a posteriori, based on the cores of meaning of the interviewees' speeches. This procedure was established by Bardin (1977), considering the technique of thematic categorical analysis.

RESULTS

In terms of structure, although this study has analyzed only three members of supply chain (coffee producers, cooperatives and development foundation) it was evidenced that this chain is composed of other links, classified as 2nd level suppliers (tangible and intangible products), 1st level customers, among which also cooperatives, along with accredited exporters, coffee shops and final customers (direct sales), as well as logistics operators. However, it is observed that the 2nd level suppliers feed the chain with supplies used for the production of inputs such as fertilizers, fertilizers, machinery, equipment, and other. They also work in the provision of financial services, insurance, consulting and soil analysis. Table 1 presents the systematization of sustainable practices and behaviors identified in the relationship between producers and cooperatives of Cerrado Mineiro Region.

Table 1. Systematization of sustainable practices and behaviors identified in supply chain

Variables and items analyzed according to Zhang et al. (2018)	Dimension of sustainability	Evidenced Practices and Behaviors	Supply Chain Members		
			producers	cooperatives	foundation
Environmental sustainability in the coffee production process	Environmental	▪ Use of Electrostatic Spraying	x	-	-
		▪ Construction of rainwater harvesting systems	x	-	-
		▪ Use of wastewater cleaning and fertigation system	x	-	-
		▪ Partial adoption of biological control of pests and diseases	x	-	-
		▪ Use of precision agriculture	x	-	-
Environmental sustainability in supplier relationships		▪ Environmental auditing for supplier selection	x	x	x
Environmental sustainability in collaboration with customers		▪ Development of biodegradable packaging	x	x	x
		▪ Gradual replacement of the use of jute packs by big bags	x	x	-
Internal Green Management		▪ Operation of the Empty Packing Processing Center	-	x	-
		▪ Trainings of employees on sustainable coffee production	x	x	-
		▪ Development of compliance and environmental audit programs	x	x	x
		▪ Implementation of environmental management systems	x	x	x
Investment Recovery	Economic	▪ Holding of open auctions for the sale of scrap of machines and equipment	x	x	-
Diversity Management	Social	▪ Hiring employees without prioritization of a particular gender	x	x	x
Development and social involvement		▪ Day of Cooperate	-	x	x
		▪ Support to regional philanthropic entities	x	x	-
		▪ Food and toy collection campaigns	x	x	-
Security Management		▪ Sizing ergonomically correct workstations	x	x	x
		▪ Use of Personal Protective Equipment (PPE)	x	x	x
		▪ Training on health and safety at work	x	x	x

Regarding the data presented in Table 1, it was verified that coffee producers, in fact, agree and recognize the importance of adopting environmentally correct practices in coffee production. The agreement level was practically 100% in all analyzed variables. It was found that, in the case of coffee producers, there is a search to improve the coffee production process in order to reduce the consumption of materials and energy, as well as to increase the recycling rate of these materials.

Another identified practice is the reduction of the consumption of water withdrawn from the riverbeds and dams by reuse of rainwater from the coffee plantations. It was verified that this practice is being adopted in nine of the twelve properties analyzed.

In the opinion of cooperative managers, even if environmental criteria are directly or indirectly considered in the choice of suppliers, it is something that needs to be more absorbed by decision-makers within cooperative organizations. According to the Cooperative Manager Range:

As much as we know the need to consider this environmental issue, we still run into the issue of price or even ease of delivery of the product we need. As we work with harvest, we can not waste planting time waiting for some supplier that has this certification, which is not easy to get (Manager 3 - Cooperativa Gama).

Considering the statemente above, it is evident that for both coffee producers and cooperatives, maintaining and controlling internal sustainability is something that is already internalized. However, when this responsibility transcends the internal barrier of ownership and migrates to the external environment, it becomes something more complex to control.

It was verified that the vision of producers, cooperative managers and Fundaccer are aligned and are moving towards cooperation between customers in the search for a more sustainable Cerrado Mineiro Region - CMR coffee crop. According to the manager of the Gama cooperative, customers need to realize that coffee production in the CMR is tied to environmental care, ranging from how to irrigate coffee plantations (with something that can reduce water consumption) to even biodegradable packaging that is used in some coffee brands.

Also regarding to cooperatives, which are generally responsible for the storage process, an interesting practice was identified regarding the physical distribution of coffee, making logistics and handling of coffee beans more efficient within the warehouses. It is the gradual replacement of the traditional jute sack (vegetable textile fiber) by big bags.

Concerning issues related to training, it has been noted that it is sometimes intermediated by cooperatives and Fundaccer with the use of their own human resources or through partnerships with other institutions, such as Sebrae and Epamig. This aspect is indicative, as Jabbour, Azevedo, and Arantes (2013) state, that there is a cross-functional cooperation involved in coffee supply chain in Cerrado Mineiro Region. We could observe the frequent involvement of the agents of this chain in order to achieve better results in terms of coffee quality and the sustainability of coffee production.

Although it was verified the existence of environmentally correct practices within the properties, it is seen that some of these (3) still do not have an Environmental Management System formally developed. This group of producers also states that there is no regular practice of audits, whether internal or external, in order to verify the compliance of environmental actions in the realm of property. It is known, however, that the Environmental Management System is voluntary, due to there is no legislation that obliges producers or organizations to implement this system in their activities.

Regarding internal green management, it was verified that all cooperatives studied developed internal practices aimed at preserving the environment. The cooperative Beta, for example, in 2003, in partnership with the National Institute of Empty Packaging Processing (inpEV) - responsible for reverse logistics of pesticides and agri-chemicals - operates the Empty Packaging Processing Center in its headquarters municipality. The plant receives packaging of pesticides and similar products already used to contribute to reverse logistics, so as not to compromise the environment. This practice is also developed in a similar way in the Alfa cooperative and in the Gama cooperative, even though it is a legal imposition, due to specific legislation regarding the handling and transportation of pesticides and also as established in the Brazilian Policy of Solid Waste – Law12,305/2010 (Barbosa, Guarnieri, & Junqueira, 2017).

DISCUSSIONS

Regarding the sustainable practices developed within the supply chain, specifically the environmental

sustainability of the coffee production process, a favorable behavior was observed with regard to the supply chain links analyzed (coffee producers, cooperatives and Fundaccer). Practices adopted to reduce the consumption of materials and energy were identified, such as (1) use of electrostatic spraying; (2) construction of systems for collecting rainwater; (3) use of wastewater cleaning and fertigation system; (4) partial adoption of biological control of pests and diseases; and (5) use of precision coffee cultivation, among others.

These actions developed by the coffee producers in supply chain, besides expanding the possibilities of commercialization of the coffee grain and also to deal with the legal issues, can improve the efficiency of the business, since the reduction of the consumption of materials and energy directly reflects in the cost of coffee production. This fact can also be seen as a competitive differential in several aspects.

Regarding the existence of environmental practices in the relationship with suppliers, it was identified that this is an action still lacking in use in supply chain. Although some of the members of the supply chain analyzed promote an environmental audit for supplier selection, this practice is not a rule, but an exception. Thus, it is understood that it is necessary to establish supplier development programs in the perspective of environmental sustainability in the relationship with suppliers. What, according to the literature, needs to be an initiative of the focal company, in this case the Fundaccer.

At the other end of supply chain, referring to the environmental collaboration with customers, it was noticed that the established practices in this sense are also moderate, as well as in the relationship with suppliers. Although most of the links recognize this importance, only two practices associated with environmental collaboration with customers were identified, with (1) the gradual replacement of the use of jute packs by big bags; (2) the development of biodegradable packaging and; (3) practice of reverse logistics. Nevertheless, the evidence suggests that supply chain members are concerned that customers value when coffee production is linked to environmental practices, otherwise they are also aware that customers can boycott coffee brands that not meet environmental or social aspects.

Regarding to the internal green management variables, it was possible to perceive that both coffee producers, cooperatives and Fundaccer carry out some type of action internally, generally related to organizational and collaborator aspects. Some properties have Environmental Management Systems, as well the cooperatives. Consequently, some properties aim to establish compliance and environmental audit programs internally, and often subject their collaborators to training on sustainable coffee production.

With regard to the economic dimension of sustainability, an interesting practice was verified in the direction of the recovery of the investment in the assets destined to the sustainable coffee production. Two of the analyzed cooperatives sell unsecured materials (scrap, for example) through open auctions, which is a practice of reverse logistics. It is a practice that aims at least to recover part of the amount invested in the acquisition of these physical assets. Indirectly, practices in this sense were also observed in the daily life of coffee farms, besides of economic and environment protection results they comply with the environmental legislation related to reverse logistics.

In the social dimension, when it comes to diversity management, no evidence has been found that there is a prioritization for hiring employees based on sex, for example. Regarding the remuneration, what was perceived is that it occurs according to the activity performed. It should be noted that diversity in the supply chain workforce can be a two-way street. One is directed to an ethical and social commitment of the company and another related to the competitiveness in terms of market. However, this research did not focus in this an issue, which can be deepened in future researches, since some studies emphasize that the feminine labor suffers salary differences.

In terms of development and social involvement, a socially responsible, if still developing, behavior of coffee producers, cooperatives and Fundaccer was confirmed with the environment in which they are inserted. Various evidences were found in this sense, such as participation in community events in the form of sponsors, days of fields open to the population, campaigns for collection of goods to be later distributed, and other.

Finally, with regard to safety management, some actions were identified in order to promote safety in the production of coffees. In addition to ergonomically designed workstations, part of the links of supply chain aims to conduct courses and promote training on aspects such as health and safety in work related to coffee.

As emphasized in the theoretical basis of this study, organizations that aim to implement sustainable practices in their productive and organizational processes within the scope of supply chain, do so as a business strategy aimed at minimizing environmental, economic and social risks and thus create and extend the corporate value (Wang, Teng, & Lou, 2014).

In the Cerrado Mineiro Region supply chain, it is clear that there is some prioritization of the customers aimed to the coffees produced with social and environmental responsibility parallel to the economic issues. Therefore, the coffee production is driven to the market and the sustainable practices have received significant attention by the members of the supply chain of coffee in the Cerrado Mineiro Region. These practices are associated with TBL concept, proposed by Elkington (1994), aiming the balance amont environmental, social and economic dimensions.

Throughout the interviews withcoffee producers, cooperative managers and Fundaccer, it was observed that there is a predisposition to implement sustainable practices in the various productive and organizational processes of coffee supply chain. The practices previously discussed and summarized in Table 1 confirm this observation and also allow to verify that many of these are developed externally, that is, there are partnerships among supply chain members to implement and operationalize such actions. It is also important to emphasize that in the supply chain of Cerrado Mineiro Region of coffee, to obtain certification of origin, producers were impelled to integrate between cooperatives and developmentfoundation (in this case, Fundaccer), which has guaranteed the quality of the product, facilitated the dissemination of sustainable practices and also made possible their export in order to access previously unexploited markets. The foundation can be recognized as focal company, governing the supply chain, while cooperatives play two roles: the supplier of inputs and also the buyer of the product.

Similarly, it has been noted that many of the drivers of the ustainable practices are also external, and it is not something that is solely a concern of supply chain members, but rather of the consumer market. These results are presented as interesting findings, since the Green SCM literature assumes that the implementation of sustainable practices in supply chain is a result of external influences, especially of pressures, incentives and demands of the clients and the government.

Finally, it should be emphasized that the discussion of public policies to promote sustainable practices in food supply chains, such as coffee, can enable the implementation of sustainable practices, as well as their improvement. This fact is also important when considering that the coffee market is based largely on international buyers, who require a sustainable positioning in agri-food production, as a requirement in the negotiations. Considering the relevant participation of agribusiness in the Brazilian, the implementation of public policies for this purpose can have favorable effects and may be the object of future research.

FINAL CONSIDERATIONS AND RESEARCH AGENDA

In this study, we aimed to identify sustainable practices adopted in coffee production in the Cerrado Mineiro Region. A number of practices were identified, which encompassed all three dimensions of sustainability, although a greater number of practices focused on environmental issues were adopted, followed by social ones and, finally, economic ones.

The contributions observed from this study are related to the systemic understanding of the way in which sustainability has been incorporated and operationalized in the coffee Cerrado Mineiro Region supply chain. Therefore, it helps managers of the organizations researched and involved in the supply chain in the decision making process, since the adoption of sustainable practices may require financial investments. On the other hand, it is also worth noting that the data presented here are evidence that the development of sustainable strategies can have positive effects for the companies studied, since these aspects have proven to improve the relationship of supply chain members, teto the most collaborative ones.

Despite the efforts and contributions of the research, it is necessary to highlight the limitations. It was decided to analyze in this paper only three links ofsupply chain covering 12 coffeeproducers, 3 cooperatives and 1 development foundation (Fundaccer). By expanding this range ofsupply chain members, including such as associations and coffee shops, other views on sustainability could emerge and motivate further discussion.

Considering the aforementioned limitations, it is recommended to further studies: (1) To explore the in-

fluences that strategic management of sustainability in agri-food supply chains can exert on the internal orientation of organizations; (2) Analyze the internal and external drivers towards the adoption of sustainable practices in the coffee Cerrado Mineiro Region supply chain; (3) Analyze the barriers faced by supply chain members towards the adoption of sustainable practices in their productive and organizational processes; (4) Analyse the social related issues, as such as, female labour force and other issues.

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THE MODERATE EFFECT OF ANALYTICS CAPABILITIES ON THE SERVICE QUALITY

ABSTRACT

This paper intends to analyze the moderate effect of organizational analytics capabilities in the development and service delivery processes, using as reference the gaps described in the Service Quality Model developed by Parasuraman, Zeithaml and Berry (1985). As a result of the analysis, five theoretical propositions were proposed, which elucidate the existing relationships between analytics capabilities and the Service Quality Model gaps, in order to generate future empirical research.

KEYWORDS | Organizational analytics capabilities, service quality, gaps, theoretical essay, business analytics.

Laís Rocha Vale
lais.r.vale@gmail.com

Larissa Alves Sincorá
larissa_sincora@hotmail.com

Letícia de Sousa Milhomem
leticiasmilhomem@gmail.com

Universidade Federal do Espírito Santo, Vitória, ES, Brazil

INTRODUCTION

The use of data to make decisions in companies of different sectors and sizes is an increasing reality in worldwide markets, and according to Bayrak (2015), the ability to manage big data will be the core competency of companies. Therefore, not only enterprises related to information technology will be able to create and improve their products and services based on data analysis, but in fact any company in any business (Davenport & Dyché, 2013).

The skill to manage Big Data may be translated into Organizational Analytics Capabilities, that are described by Davenport, Cohen, and Jacobson (2005) as a portfolio of data analytics methods and tools. The presence of these capabilities in an organization means that it has technical skills and ability to collect relevant data, use data analytics statistical models and, most importantly, the capacity for doing simulations and using those analyses to make strategic decisions.

In line with this, Bayrak (2015) affirms that the development of organizational analytics capabilities helps expanding the offer of products and services, and when developing an analytics culture, organizations may increase service quality, reduce operational costs and increase return on assets (IBM, 2017).

From these perspectives present in the literature, that point towards the influence of analytics capabilities on the delivery of services, this paper intends to study the following research question: the existence of organizational analytics capabilities can cause impact in the service quality perceived by customers? This question becomes relevant, since the understanding of the factors that influence the clients' perception of quality, and the inclusion of those factors in the service compound, is a determining matter to the success of service companies.

The choice of the service sector as the object of analysis was due to its importance to the national and global economy. Service companies are responsible for 68% of Brazilian GDP (Pereira, 2014) and they represent approximately 60% of the foreign trade in developed countries (MDIC, 2017). By developing an analytics organizational culture, service companies will be able to offer services that suit specific needs of the customers and, as a consequence, to obtain a better perception of quality from them.

Companies such as Boston Red Sox, Netflix, Amazon.com, CEMEX, Capital One, Harrah's Entertainment, Procter & Gamble and Best Buy use analytics capabilities to build their competitive strategies, guide their decision-making processes and win the competition. When applying such analytics skills, those organizations identify the most profitable customers, accelerate the innovation of products and services, optimize the supply chains and the pricing (Davenport & Harris, 2007).

In this study it will be used the concept of Perceived Service Quality, measured from the perception of quality by customers (Parasuraman, Zeitham, & Berry, 1988), being the 5 Gaps model, proposed by Parasuraman et al. (1985), the tool used here. In this model Parasuraman et al. (1985) affirm that the perceived service quality is a result of the magnitude of the Gap 5 (the gap between the service offered by the companies and the service perceived by the customers), and this one depends on the magnitude of the other four Gaps, that may be favorable or unfavorable. The management of the service quality (Gap 5) depends, thus, on the control of the individual effect of each of the other gaps, being necessary to seek for tools that may minimize the negative effect that these gaps may cause on the service quality.

Therefore, the general objective of this study consists of analyzing the moderate effect of organizational analytics capabilities on the gaps described in the Service Quality Model of Parasuraman et al. (1985). In order to reach this general objective, it is proposed to identify the relevant dimensions to understand the "Service Quality" and "Organizational Analytics Capabilities" constructs, and the possible relationship between them. This understanding emerged from the results obtained in a systematic literature review, focused on the key topics of this paper, such as service quality, analytics capabilities, big data and business analytics.

For this purpose, first it is presented the theoretical frame, bringing a discussion about the "Service Quality", where it is presented the 5 Gaps Model of Parasuraman et al. (1985), and "Organizational Analytics Capabilities" constructs, presenting the variables that compose this last one. This literature review aims to dimension and delimitate the key concepts of the study. After that, it is carried out an analysis of the relationship between Organizational Analytics Capabilities and the 5 Gaps Model of Parasuraman et al. (1985), aiming to relate the existence of analytics behavior to each of the five gaps of the model, therefore presenting the theoretical propo-

sitions and the structural model that evidences the relationship. Finally, there are the conclusions and suggestions for future research.

THEORETICAL FRAME

In order to define the theoretical discussion proposed by the research objective of this study, it was performed a literature review relevant to the discussion, aiming to delimitate the theoretical assumptions, the constructs and the relationships between the variables that compose the research model suggested. The theoretical frame serves as a basic theory to answer the research questions of this paper, as well as the foundation of the theoretical relationships presented in the research model.

Service Quality

To the majority of the service companies, the concern with quality has become a fundamental factor to develop the business strategy, because it has great influence on the company's performance and it impacts positively customers' satisfaction (Akbar & Parvez, 2009; Bloemer & Kasper, 1995; Huang, Tseng, & Hsu, 2016; Johnston, 1995; Oliver, 1997; Orel & Kara, 2014; Prado & Marchetti, 1997; Spreng & Mackoy, 1996; Sureshchandar, Rajendran, & Anantharaman, 2002). Specifically to the service sector, delivering to the customer a service with superior quality has become a prerequisite to the success of this kind of business (Parasuraman et al., 1988), since, and unlike it happens with products, the perception of service quality occurs through the subjective analysis of who's consuming it, and not through specific physical characteristics that are easy to control, demanding, thus, an efficient structure of quality management, that enables the survival of the organization in its competitive market.

The processes of production and delivery of the service have particular characteristics that make it difficult to determine the aspects that define its quality. These characteristics are the intangibility, heterogeneity and inseparability of the production from the consumption (Grönroos, 1982; Parasuraman et al., 1985, 1988; Stefano, Casarotto Filho, Barichello, & Sohn, 2015), and there is also the perishability as a fourth characteristic mentioned by some authors (Ghobadian, Speller, & Jones, 1994). These characteristics refer to the fact that the process of service production occurs simultaneously with its consumption, turning the storage into something unlikely to happen and causing the customer to be an acting part of the production. Concerning the participation of the customer, it causes the service delivery to be heterogeneous, for each experience depends on the factors and actors involved. These characteristics turn the relationship between customers and a service company different from the relationship between a goods company and its clients (Grönroos, 1982).

Ghobadian et al. (1994) affirm that customers usually look for signs of quality in the products and services, that may be users' opinions, reputation, accessibility, communication, physical aspects, etc., but, specifically in the services, the influence of intangible aspects on the purchasing decision is much higher than the influence of tangible aspects on the purchase of a product. That causes service companies to have a greater responsibility to understand the aspects of the service that are interesting to their customers, to create expectations through external communication and to provide a service that matches, or excels, from the very first contact, the expectations that were created.

Customer's expectation is held as a standard which will be compared to the following experiences, resulting in an answer, that is the perceived service quality (Parasuraman, Berry, & Zeithaml, 1993)Churchill, and Peter's (1993. To Ghobadian et al. (1994), the expectation is the image that the customer has of the service before consuming it, that may be influenced by external factors and, consequently, it may be shaped by the company through its efforts of marketing and communication with the client.

On the other hand, Johnston (1987) argues that the customer's expectation is dynamic, that is, it changes as the delivery stages advance, being influenced by different factors. To this author, expectation must be analyzed before the consumption experience, not measured after the experience, as proposed by Parasuraman et al. (1985) and corroborated by other authors.

This difference between the arguments referring to the use of expectation as a relevant factor to measure service quality represents a great divergence among the authors in this field. Regarding the measurement of the quality service construct, there are two main research lines that discuss in which way the quality service should be measured (Dabholkar, Shepherd, & Thorpe, 2000; Santos, 2003)difference scores.

Some authors defend the disconfirmation, a concept proposed by Oliver (1980) and widely used in the lit-

erature of service quality (Santos, 2003), as a way of measuring service quality, consisting of measuring the expectation of the customer and the perception of the service after the consumption, and the perceived quality is the result of the difference between the grades of the expectation and the perception (Grönroos, 1982; Parasuraman et al., 1985, 1988).

That way, having the service quality as a result of meeting customers' expectations, Parasuraman et al. (1988) developed a measurement scale called SERVQUAL, refined later by the authors (Parasuraman, Berry, & Zeithaml, 1991), that measures the perceived service quality based on 5 determining factors. This scale is still the most used one in the relevant literature to analyze service quality (Mondo & Fiates, 2013).

However, the SERVQUAL measurement scale has been criticized over time by some authors (Babakus & Boller, 1992; Cronin Jr & Taylor, 1994) that follow a second line of thinking, in which they believe that measuring only the customer perception, putting aside the expectation, is enough to measure service quality, which resulted in the creation of the SERVPERF (Cronin Jr & Taylor, 1994), a scale similar to the SERVQUAL, but only with questions aimed at capturing customer's perception.

Brown, Churchill, and Peter (1993) also criticized the SERVQUAL scale, however they questioned its psychometric qualities, and they were promptly answered by Parasuraman et al. (1993), that, in the same edition of the Journal of Retailing, defended the validity of the scale. Dabholkar et al. (2000) point out that the SERVQUAL fails when assuming that the quality measure may be obtained with the average of the five dimensions that compose the scale, since in that way it does not capture the individual effect of the dimensions, as it treats the dimensions as components of the construct, not independent antecessors.

In this context of divergences regarding the measurement of service quality, many conceptual models of service quality have been developed (Beddowes, Gulliford, Knight, & Saunders, 1987; Haywood-Farmer, 1988; Johnston, 1987; Moore, 1987; Nash, 1988; Parasuraman et al., 1985; Yang, Jun & Peterson, 2004), with different intentions and applications, though, where some offer mechanisms for managers to implement and manage a quality control system, and others help realizing internal and external factors that influence the customer's service quality perception (Ghobadian et al., 1994).

Given the evolution of the discussion about service quality, there is currently (in the literature directed to the marketing area) the service quality management being treated as a topic that is slowly giving rise to what is called the service-dominant logic. According to Gummesson, Lusch, and Vargo (2010), quality is no longer a recurrent word in service-dominant logic, since the word "value" has taken its place. In this perspective, one intends to understand how the client creates value to himself from the consumption of the service (Grönroos, 2008).

In other areas, such as operations management, that also discusses about service quality (Jayaram & Xu, 2016; Kress, & Wisner, 2012; Wen, Prybutok, Blankson, & Fang, 2014; Yang et al., 2004), there has been discussed the relationship of technology and its impacts on quality perception, bringing e-Service as a recurrent point of debate, since the growth of online services has caused the geography to have an even lesser role in the competitive strategy, causing the costs of changing suppliers to be linked to the convenience and utility of time, and promoting service quality to a factor even more relevant in the differentiation among competitors and in the attraction and retention of customers (Yang et al., 2004).

Nevertheless, despite the criticisms suffered over time and the new perspectives to the researches about service, the SERVQUAL scale is still largely used in studies about service quality (Chenet, Tynan, & Money, 2000; Jamal & Anastasiadou, 2009; Kumar, Tat Kee, & Charles, 2010; Mohebifar, Hasani, Barikani, & Rafiei, 2016; Stefano et al., 2015)namely conventional and Islamic, in terms of common critical factors after re-examining the SERVQUAL model, originally pioneered by Parasuraman. Further, the technique of dominance analysis is used to examine the relative importance of the critical factors in closing up the overall service quality gap in these two types of banks. Design/methodology/approach: The sample is made up of 308 bank customers, consisting of the customers from both Islamic and conventional banks from different parts of Malaysia. The data have been collected by using the structured questionnaire, which consists of three parts. Part 1 deals with consumers' usage of banking channels and their banking behaviour. Part 2 contains 26 statements related to service

quality dimensions based on past literature. Finally, Part 3 contains the questions related to the socio-demographic profiles of respondents. Findings: The modified SERVQUAL model consists of four critical factors (dimensions. The service quality model developed by Parasuraman et al. (1985), which considers the existence of important gaps regarding the corporate executive's perception of the service quality and tasks associated with service delivery to customers, is still a valid basic theory to understand the obstacles in the processes of development and delivery of a service.

Therefore, this research adopts the traditional approach of disconfirmation, that quality can be measured from the difference between the expectation and perception of the service. This scale, when used in researches that intend to study a specific market, may be adapted to better represent the characteristic language of the environment researched, without losing, though, its backbone, that is the five dimensions of quality and its way of measuring the results. However, in this research, as it is not evaluating any market specifically, and because it considers the SERVQUAL scale a valid generic scale, there will be no adaptations.

In order to reach the research objective, which is to understand the impact of the organizational analytics capabilities on the five gaps of the Service Quality Model of Parasuraman et al. (1985), it is presented in the following section a further detailed explanation on the Service Quality Model of Parasuraman et al. (1985), analyzing each of the five gaps delimitated by the authors.

Service Quality Dimensions – 5 Gaps Model

Based on a research carried out with managers of companies related to four different sectors – retail bank, credit cards, securities brokerage and repair and maintenance of products and service – and their respective customers, Parasuraman et al. (1985) noticed along the research that there was a set of gaps linked to the perception of the managers about the service quality and the tasks related to the delivery of services to customers, and that those gaps could disrupt the delivery of a service of quality in the perspective of the customers.

Thus, they created a model that helps identifying the failures in the quality of the service, working as a diagnosis tool (Ghobadian et al., 1994). The first gap (Gap 1) is the "difference between the customers' expectations and the perceptions of the managers about the customers' expectations" (Parasuraman et al., 1985, p. 44). This gap exists when the manager has an inconsistent perception about what the customer really wants, and the reason of its existence is the lack of focus properly directed to the market (Ghobadian et al., 1994). Huang et al. (2016) refer to this gap as the knowledge gap.

The second gap (Gap 2) is "the difference between the perceptions of the managers regarding the customers' expectations and the definition of the service quality specifications" (Parasuraman et al., 1985, p. 45). This occurs when the managers cannot specify the proper standards to the service, so that they are in accordance with the customers' expectations (Huang et al., 2016. According to Parasuraman et al. (1985); there is often the knowledge of the expectations, but it lacks the means to meet them. Huang et al. (2016) refer to this gap as the design gap.

The third gap (Gap 3) is "the difference between the service quality specifications and the effective delivery of the service" (Parasuraman et al., 1985, p. 45). This gap occurs when the service delivered is different from the service designed by the manager. Parasuraman et al. (1985) points out that, in their research, the managers acknowledged that the employees of a service company have a strong influence on the perceived quality and that it is not always possible to standardize the service delivered. Huang et al. (2016) refer to this gap as the performance gap.

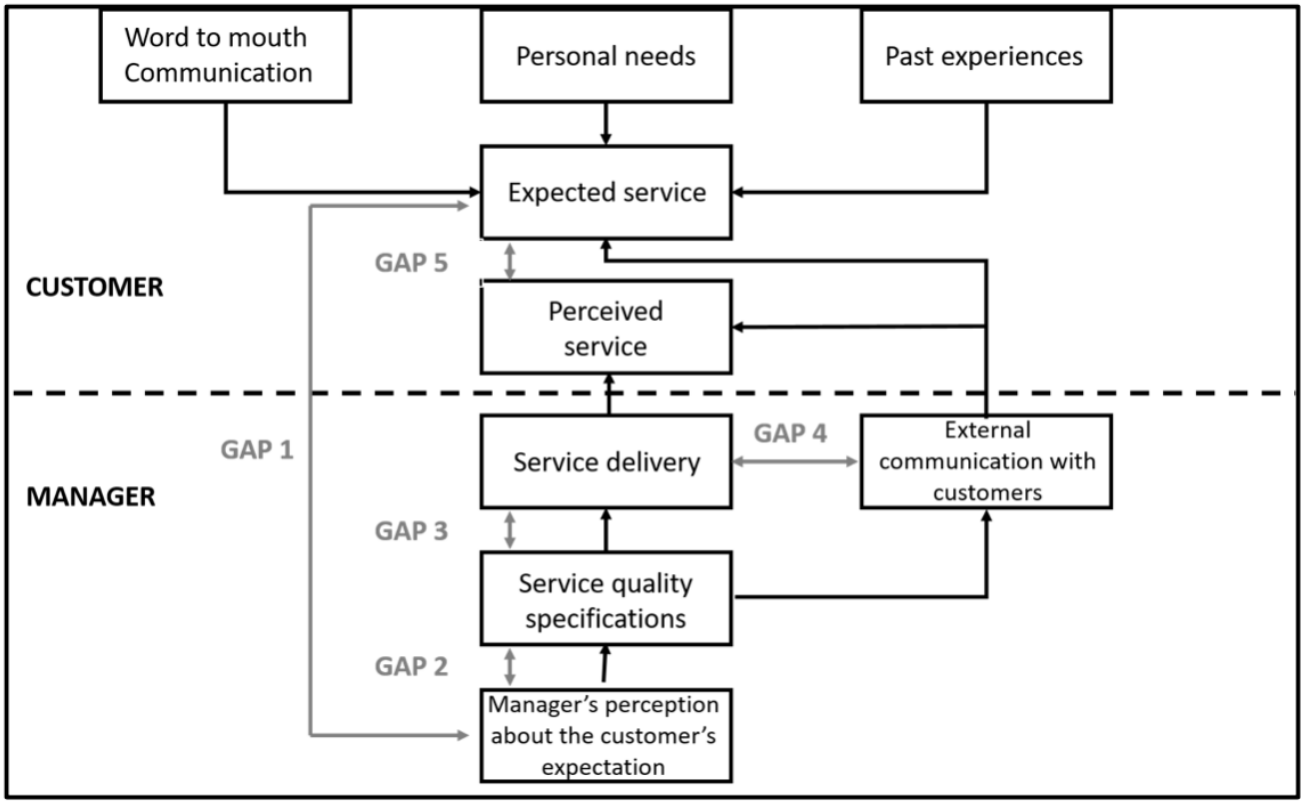
The fourth gap (Gap 4) is "the difference between the real delivery and the external communications about the service" (Parasuraman et al., 1985, p. 46). Parasuraman et al. (1985) points out that it is necessary to pay attention to not promote a service with more benefits than it can be delivered, because it raises the expectation and, when they are not met, it causes lower perceptions of quality. Huang at al. (2016) refer to this gap as the communication gap.

The fifth, and last, gap (Gap 5) is "the difference between the customer's perception related to his experience and his expectation about the service" (Huang et al., 2016, p. 88), and this gap is affected by the previous 4 (Huang et al., 2016; Parasuraman et al., 1985)based on the relevant literature and the operational features of air freight carriers, the service requirement attributes (SRAs. Parasuraman et

al. (1985) refer to this gap as the service quality perceived by the customer.

In the model presented by the authors (Figure 1), the gaps shown as Gap 1, Gap 2, Gap 3 and Gap 4 occur during the stage of design and delivery of the service, being caused, thus, by the managers. Regarding Gap 5, that measures the perceived service quality, it is caused by the customer.

Figure 1. Service quality model



Source: Parasuraman, Zeithaml and Berry (1985). Adapted by the authors.

The manager is not capable of foreseeing all the needs and desires of all its customers and adjusting the offers according to the necessary level to meet those demands (Parasuraman et al. 1985). Therefore, the use of tools that help monitoring and gathering information about the customers is fundamental, allied with the development of analytics capabilities that can effectively bring advantages to the organization. Thus, aligned to this understanding, it is discussed in the next section about the concept of Organizational Analytics Capabilities and the strategic importance of developing those to the organizations.

Organizational Analytics Capabilities

In order to be successful in the activities of analysis and extraction of valuable information from data, it is necessary to develop more than just generic practices recommended by specific knowledge corpus. It is needed to develop an entrepreneurial culture that values decision-making based on data (Davenport, 2006), so that it is possible to provide results, identify better market opportunities and make assertive decisions.

In the current globalized scenario, with fast communication and easy access to information, companies have started to own a great amount of data available, but in most cases they cannot turn those data into useful strategic information (Azimuddin & Karunesh, 2011). Organizations face different types of problems in their routines, which demand fast and precise decision-making, and that may demand from the manager a series of abilities and skills to access the best solution given the information available.

These abilities and skills to extract relevant information from data are called analytics capabilities and

this concept emerges from the discussions about Business Analytics (BA) (Sincorá, 2016; Sincorá, Oliveira, Zanquetto-Filho, & Ladeira, 2018). Analytics capabilities are part of a set of variables that form the BA construct, that, in its turn, is seen as a sub-group of Business Intelligence (BI) (Azimuddin & Karunesh, 2011; Longo, Giacovelli, & Bochicchio, 2014), this one being defined as "an umbrella term for an enterprise-wide set of systems, applications and governance processes that enable sophisticated analytics, by allowing data, content, and analysis to flow to those who need them, when they need them" (Azimuddin & Karunesh, 2011).

BA is defined by Khan and Saxena (2011) as a critical component of BI, because, through technologies and processes, it extracts relevant information from data to analyze business performance. Corroborating with the previous definition, Longo et al. (2014) define BA as being responsible for creating, in organizations, "capabilities to be competitive through processes and procedures, that can be used to analyze data, in order to improve business performance through facts-based decision-making" (Longo et al., 2014).

The BA concept became stronger after Davenport's publication of the paper named "Competing on Analytics" in 2006 in the Harvard Business Review (Bronzo et al., 2013) and, since then, it has been gaining notorious space among management paradigms (Delen & Demirkan, 2013). That occurs because companies have been increasing the generation, storage and sharing of data, and BA proposes, among other things, the possibility of data capitalization (Bayrak, 2015), for organizations stop spending money solving problems to seek to optimize the use of their capital (Davenport, Cohen, & Jacobson, 2005).

However, in order to have an organizational strategy addressed to optimization and with an implemented analytics culture, it is necessary to use the available data volume, be capable of analyzing those data, understand and make predictions based on that analysis and use the information generated as a support, or input, to the decision-making, besides having professionals who are technically capable of understanding the importance of data usage for the decision-making (Davenport et al., 2005) and extracting value from data. If the analytics perspective is not present in the company at the strategic level, the decision-maker will not know in which data he should focus or which goal must be achieved with the data analytics (Davenport, Harris, De Long, & Jacobson, 2001).

In their research, SAS (2013) and Davenport et al. (2005) highlighted, respectively, metrics and steps to understand the analytics efficiency level of the companies and the necessary characteristics to compete analytically. Those metrics and steps presented in these two studies have several common points that, in short, discuss the adoption of technology, processes, big data, analytics business strategy and the need for having analytics capabilities able to operationalize all these tools.

Analytics capabilities, a characteristic pointed out by Davenport et al. (2005) as one of those which form the BA construct, and the focus of this section, are described as "(...) a portfolio of analytics methods and tools. They include tools that support traditional *ad hoc* queries, inferential statistics, predictive analytics, simulation, and optimization, thus supporting descriptive, diagnostic, predictive and prescriptive analytics" (Acito & Khatri, 2014, p. 567). Sincorá (2016; 2015) when performing a mapping of the scientific productions in BA of the last 11 years (2004 to 2015), aiming to define the variables that compose the organizational analytics capabilities, concluded that organizational analytics capabilities refer to a second order construct formed by three first order constructs, which are: statistical capabilities, business capabilities, and information technology capabilities. In this study it will be adopted the organizational analytics capabilities concept presented by Sincorá et al. (2018).

To Sincorá et al. (2018), statistical capabilities are the "ability to develop logical, critical and analytical reasoning about the organizational reality based on quantitative data" (p. 38), and their indicators are the elaboration of inquisitive, descriptive, predictive and prescriptive analyses. Business capabilities are the ability of making decisions based on data and facts, that is, extracting information from the available data, so that it helps identifying problems, developing and implementing solutions. Their indicators are: "clear communication of business problems; data translation into business perceptions; interpretation of analyses from statistical models; and decision-making based on facts and data" (Sincorá et al., 2018, p. 38-39).

Information technology capabilities are described as the existence of technical skills enabling the use of hardware and software that allow making com-

putational modeling, having as indicators: "data exploration; data hygiene; data integration; and creation of big data environments" (Sincorá et al., 2018, p. 39-40).

Therefore, the present study focuses on understanding the way in which the existence of analytics capabilities in service companies may impact the existing gaps in the process of designing and delivering the service, described in the model of Parasuraman et al. (1985), presented in the previous section. In order to do so, the next section discusses the way in which the analytics capabilities can relate to the 5 Gaps Model, where it is presented the theoretical propositions, final objective of this paper.

Organizational Analytics Capabilities and the 5 Gaps Model

Many researches about BA, BI and Big Data have been showing that the adoption of analytics strategies and tools and the development of analytics capabilities create positive results in organizations (Chae, Yang, Olson, & Sheu, 2014; Thomas H. Davenport, 2006; IBM, 2012, 2017; Lavalle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011; SAS, 2013). LaValle et al. (2011) in their research, to which it was interviewed 3,000 corporate executives of companies with different sizes and nationalities, reported that companies which declared having a superior performance over their competitors, have used BA in their activities five times more than the ones which declared having a lower performance.

IBM (2012), together with the Saïd Business School of Oxford University, conducted a study with 1,144 information technology companies and professionals in 95 countries, where it was asked which were the main functional objectives to use big data in their organizations. As a result, 49% of the interviewees affirmed that the main objective was to achieve customer-focused results, which demonstrates the important role of data usage and the development of analytics capabilities to understand and predict customers' behavior, therefore, improving their experience.

For service companies, that have strategies addressed to seek customer-focused results, the necessity of understanding customers' behavior and predicting their choices is essential, because quality perception, as seen before, depends on the previous expectation of the customers, and understanding which are these expectations is crucial to the success of these organizations.

Those information about the customer together with the development of statistical, business and information technology capabilities, support the manager to create a more realistic image of the customer's preferences and demands, causing a sensible reduction in the gap between the service expected by the customer and the manager's perception about this customer's expectation, that is, in the Gap 1 of the model of Parasuraman et al. (1985). This way, it is introduced the first proposition of this study:

P1: The existence of organizational analytics capabilities moderates the relationship between the manager's perception about the customer's expectation and the service expected by the customer (Gap 1), diminishing the gap between these two constructs.

The development of analytics capabilities in organizations may increase service quality, reduce operational costs and increase return on assets (IBM, 2017), besides supporting the expansion of products and services offer (Bayrak, 2015). Nevertheless, many companies have not used this analytics approach yet, and keep dealing with manual tools and intuitive management, to draw conclusions about data and act to improve operations (IBM, 2017), which turns up to be an under-usage of the collected data, missing to extract valuable information to the decision-making. Corroborating with this perspective, Davenport and Dyché (2013) say that "the primary value from big data comes not from the data in its raw form, but from the processing and analysis of it and the insights, products, and services that emerge from analysis."

Therefore, based on these discussions, it is possible to affirm that the development of statistical, business, and technology capabilities support the creation of new services, causing the manager to create or improve products that have the characteristics necessary to meet the customer's demand, besides promoting the essential conditions so that the customer has access to these characteristics and he is able to notice that his expectations were met, during the delivery of the service. That way, there are the second and third propositions:

P2: The existence of organizational analytics capabilities moderates the relationship between the

manager's perception regarding the customer's expectation and the development of the specifications (design) of the service that will be delivered (Gap 2), diminishing the gap between these two constructs.

P3: The existence of organizational analytics capabilities moderates the relationship between the service design and the service delivery (Gap 3), reducing the gap between these two constructs.

According to what has been discussed along this paper, customer's quality perception depends on several stimuli that build the customer's expectation and the image that he has of the service before consuming it, which may be influenced by factors such as personal needs, past experiences, word of mouth, market communication, image and price, and, consequently, it can be shaped by the company that provides the service, through efforts directed to marketing and external communication (Ghobadian et al., 1994).

Thus, it is possible to notice that the external communication about the service characteristics, which get to the client through marketing actions, are factors that influence on the creation of expectations related to the consumption of service, and, therefore, also influence on the perceived service quality. This way, the characteristics of the service that must be advertised are the ones related to the customer's desires and easily noticed by him during the production and consumption of the service, so that the organization does not communicate characteristics and benefits that is not able to provide or that will not be easily noticed.

In this context, the creation and observation of indicators to control the service production process quality helps the manager to understand the strengths and weaknesses of his processes and use this information to highlight the strengths in the advertisements. That is, the existence of organizational analytics capabilities supports the creation of a realistic advertising, showing what is in fact offered to the customer, generating an expectation that can be achieved by the service that will be offered.

Therefore, using statistical, business and technology capabilities to create an efficient communication and, as a consequence, diminishing the gap between the characteristics of the service advertised and the characteristics of the service offered is fundamental, so that the perceived service quality is the best possible. So, it is presented the fourth proposition:

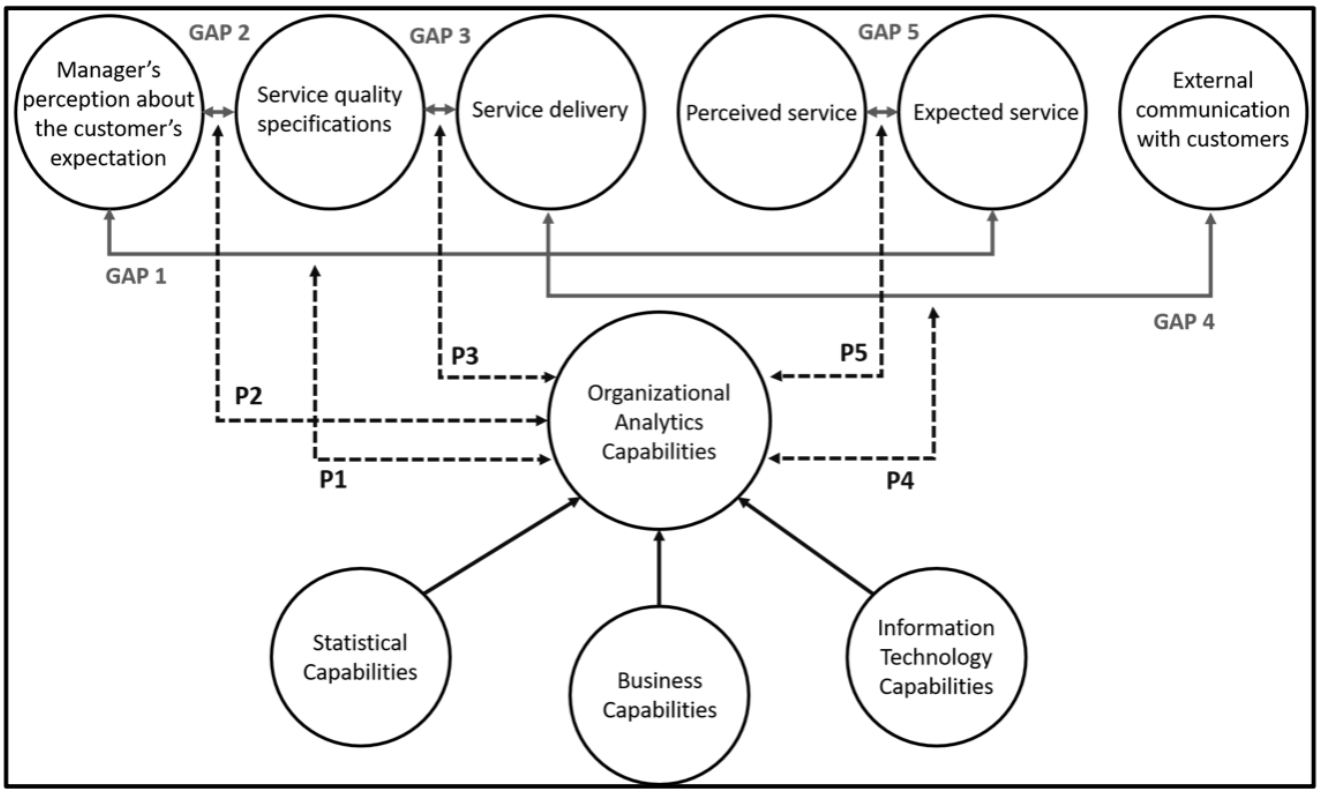
P4: The existence of organizational analytics capabilities moderates the relationship between external communication with customers and the service delivered (Gap 4), reducing the gap between these two constructs.

According to Parasuraman et al. (1985), the perceived service quality depends on the size and direction of Gap 5 (the gap between the service offered by the companies and the service perceived by the customers), and this one depends on the size and direction of the other four Gaps, that may be favorable or unfavorable. To improve service quality, represented in the model as the Gap 5, the manager needs to understand the individual effect of each of the four remaining gaps (Huang et al., 2016) and seek for tools that minimize the negative effect these four gaps may cause in the service quality. Therefore, it is presented the fifth proposition:

P5: The existence of organizational analytics capabilities moderates the relationship between the service expected and the service perceived by the customer (Gap 5), reducing the gap between these two constructs.

This way, the research model and the propositions presented in this section are represented in Figure 2.

Figure 2. Initial structural model and propositions



METHODS

This theoretical essay has a critical, reflexive, and positioned approach, since, based on the results obtained from a systematic literature review, it was possible to draw lines and structures to discuss the theme of this text: the moderate effect of analytics capabilities on the service quality.

This way, it was carried out a mapping of scientific productions on Service Quality and Business Analytics from the last six years (2013 to 2018) in three research databases in the field of Social Sciences (WEB OF SCIENCE; CAPES SCIENTIFIC JOURNALS and GOOGLE SCHOLAR). The articles were collected based on the use of the keywords "service quality", "service quality dimensions", business analytics", "business intelligence" and "big data", searching for the referred term in the title, abstract or keywords of the articles published in the databases consulted.

FINAL CONSIDERATIONS

The aim of this study was to propose a new analysis approach of the 5 Gaps Model of Service Quality suggested by Parasuraman et al. (1985), seeking to evaluate a possible relationship between the existence of organizational analytics capabilities and a shorter distance between the manager's understanding of the customer's needs, the specifications and delivery of the service, the customer's expectations and his perceptions after the consumption experience.

In order to better enlighten the proposed relationship, five theoretical propositions were created, which evidence the way in which analytics capabilities impact the perceived service quality. According to the propositions, as the analytics capabilities influence the perception of the customer's demand, service design, service delivery and in the way in which the service is communicated (gaps 1, 2, 3 and 4), it will also be impacting on the service quality perceived by the customer (gap 5). Therefore, these propositions corroborate with the idea exposed by IBM (2017), when it says that the development of an analytics culture may increase service quality, reduce operational costs and increase return on assets.

For management purposes this research is relevant because markets are quickly introducing new technologies that enable the improvement of data collection and management, but often do not invest in the development of organizational capabilities that are capable of turning this data into answers. Thus,

this study focused on demonstrating the importance and the impact of those investments, aiming to stimulate them.

For academic purposes, the contribution occurs by opening new possibilities for empirical tests that can prove or refute the propositions presented here, therefore contributing to the discussions within the area of service quality and business analytics. It is suggested that future research study whether the presence of analytics capabilities is enough to create impact on the service quality or the maturity level of those capabilities would cause more impact on this relationship. The maturity level of the analytics tools in an organization has been discussed already, such as in the work of Davenport et al., (2005), and it is an interesting perspective to deepen the discussion proposed in the present paper.

Despite the contributions that this study may propose, limitations were found, such as the necessity of testing the propositions empirically. Based on empirical tests it will be possible to understand if the organizational analytics capabilities impact all the stages of the service development and delivery, present in the 5 Gaps Model, in a way that the customer can notice the improvements, or if the analytics capabilities allow internal improvements (with no less importance, though), with an impact that is only noticeable to the internal components of the organization. These tests could be performed based on quantitative research, aiming to validate the five propositions presented, or even qualitative research, that seek a deeper reflection on the relationship proposed between the constructs presented here.

In addition, this research aimed to demonstrate that the customer-oriented organizational focus, whether in the implementation of new processes, new technologies or creation of new services, is a decisive factor for a better evaluation of the service quality by customers.

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