Contract Design for Rice Flour Supply Chain: Shipment Planning, Routing, Scheduling, and Invoicing

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ABSTRACT

The lack of proper planning and scheduling in the shipping process within the rice flour supply chain has resulted in various challenges, including missed products for consumers. This issue is particularly concerning due to the delicate nature of rice flour, which has a limited shelf life. Implementing a contract-based supply chain information system has proven to be beneficial in improving transparency and facilitating clearer information on product specifications to customers. The contract played an essential role because of the ability to adjust the description of a specific goal, enabling each supplier to customize the contract according to their needs. This customization includes specifying the duration of the product delivery process and the timeline for when consumers can expect to receive the product, thereby ensuring clarity and mutual understanding between all parties involved. Therefore, this research aimed to design business processes within the rice flour supply caused by using a contract, with a focus on minimizing distance and delays in routing and scheduling. Furthermore, it integrates the results of scheduling and routing with a contract in the form of invoices. The saving matrix method was used to calculate efficient shipping routes for distribution activities, resulting in a refined contract design tailored for rice flour transactions. The stakeholders included were the shipper manager, marketing department, and customers. By applying the saving matrix, this research effectively planned shipment scheduling and routing, optimizing the entire logistic process in the industry, and a prototype invoice design was developed for rice flour customers.

Keywords: Contract; invoice; rice flour; shipment planning

INTRODUCTION

Customer concerns regarding product delivery are significantly impacting trust levels, showing the need for supply chain stakeholders to implement policies ensuring transparency and fostering mutual trust. Integrated service providers in the supply chain can leverage information technology to streamline information flow (Wong et al., 2009). One effective solution includes using a contract to provide customers with essential information and build trust. In various industries, using a contract has proven effective in increasing customer confidence in the delivery of goods.

An invoice is a document used to record sales transactions, which serves as a form of contract between the customer and the company, attaching notifications of order fulfillment and shipping, thereby becoming supporting data. This includes important information

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about the order such as the invoice date, item details, order number, total bill information requiring approval, and the delivery date (Ma'sula & Irfa, 2018).

The invoice contains shipping planning information, which includes scheduling and arranging shipping routes. Delivery planning uses the saving matrix method in determining the optimal time frame for shipping goods. The saving matrix is a method that illustrates the savings obtained by combining two agents in one vehicle (Ahmad & Muharram, 2018), enabling the calculation process to generate efficient shipping routes for consumer distribution activities (Sarjono, 2014). This method produced passages efficiently (Pattiasina et al., 2016), and was used to determine delivery schedules to customers.

The rice flour industry faced significant challenges due to poor planning and scheduling of the shipping process, leading to delays in product delivery to consumers. This was caused by the perishable nature of rice flour, which easily deteriorates and has a limited shelf life. Moreover, the reliance on management intuition for shipping planning further compounded these issues, resulting in late deliveries and decreased product quality. This reliance on paper-based contract and invoices further hindered transparency and accountability in the shipping process, making it difficult for customers to access vital information about their products. The lack of a transparent supply chain information system meant that customers were unable to track their orders effectively. This reliance on paper-based contract and invoices further hindered transparency and accountability in the shipping process, making it difficult for customers to access vital information about their products.

According to Wang et al. (2016), addressing these challenges required the implementation of a transparent supply chain information system. This type of system would not only improve customer satisfaction by providing real-time tracking of orders but also enhance overall the distribution of perishable food products. This is crucial given the importance of timely delivery in maintaining product freshness and quality. By optimizing agricultural product delivery processes, businesses can reduce shipping costs and increase customer satisfaction, thereby ensuring the competitiveness and sustainability of the rice flour industry (Vlajic et al., 2012).

In this case, the contract played a role in various industries by providing a framework for specifying and achieving specific goals. Across sectors such as pharmaceuticals, project management, and real estate, contract are used to establish agreements between parties. For example R&D contract is important for the timely development of urgently needed drugs (Choi et al., 2023), project management contract (Cai et al., 2023), and real estate industry contract (Ullah & Al-Turjman, 2023) facilitate smooth operations within their respective industries. In the context of the rice flour industry, a contract is indispensable for fostering trust and ensuring the sustainability of the business. They serve as a medium to outline clear expectations and responsibilities, thereby enhancing transparency and accountability throughout the supply chain. By incorporating specific delivery terms into a contract, suppliers can streamline the product delivery process and provide customers with accurate information regarding delivery timelines. This research aimed to leverage a contract as a tool for designing efficient business processes within the rice flour supply chain. By minimizing distance and delay in routing and scheduling and integrating the results of scheduling and routing into contract terms in the form of invoices. This approach not only enhances customer satisfaction but also contributes to the long-term viability of the rice flour industry.

METHODS

Research Framework

The research framework served as a sequential approach to guide the completion of the research objectives. Figure 1 describes the overview of the research framework.

Time, Place, and Research Data

This research was carried out in two rice flour, small and medium enterprises located in Banten, Indonesia, spanning a duration of six months (January to June 2019). The research methodology included conducting interviews to gather insights into the current practices regarding the utilization of a contract in the supply chain within the industry. Additionally, hypothetical location data was generated, represented as integer random numbers ranging from 0 to 150. These numbers corresponded to the coordinate point of customer location. To construct the model, ten records of the customer location data were used. The generated data was used to design the shipment planning, routing, and scheduling using the saving matrix method.

Design of Business Process with Business Process Modeling Notation (BPMN)

The BPMN method was used to address the research objective of designing the actors and defining their roles within the rice flour supply chain, particularly

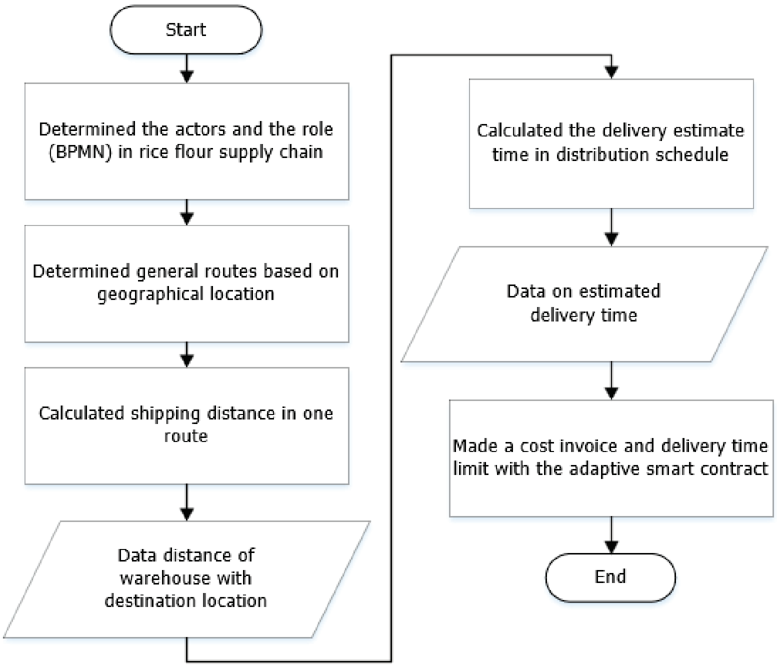

Figure 1. Research framework

focusing on aspects related to contract design, such as shipment planning, routing, scheduling, and invoicing mechanisms. The BPMN serves as a powerful tool for comprehensively illustrating business processes (Valacich & George, 2017). This method serves as a visual representation of business processes, detailing the methods employed and assigning responsibility to stakeholders. It elucidates the stakeholders included, their roles, the activities they carry out, and the data they access at each stage of the process. This comprehensive overview ensures clarity and efficiency in understanding and executing business operations (Wasson, 2016). Furthermore, BPMN played a significant role by identifying the actors involved in the supply chain of the system being developed. It also explained whether actors faced alternative conditions through the gateway icon or had specific requirements to start their activities, such as waiting for data from other actors (Banuelos, 2016).

Saving Matrix

The saving matrix method was used to determine the delivery route and schedule including several stages: (1) determining the distance matrix, (2) calculating the saving matrix, (3) allocating each point of location to the route, and (4) sorting points of location for each route (Lukmandono et al., 2019; Suparjo, 2017). In the first stage, the process involved determining the coordinates of customers relative to the position of the shipping goods. Subsequently, each distance between customers was computed using Equation 1.

$$J(A,B) = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2} \quad (1)$$

Where X_A and Y_A were the coordinates of point A and X_B and Y_B were the coordinates of point B.

In the second stage, the assumption was that the customer visited every delivery of the goods, and the formulation follows Equation 2.

$$S(x,y) = J(0,x) + J(0,y) - J(x,y) \quad (2)$$

Where x and y were customers and J was a distance between customers.

The customer pairs were combined with the highest saving shipping distance in the third stage, and the delivery order was determined with the nearest neighbor procedure in the fourth stage. After getting the delivery order, the shipping distance was obtained and the delivery schedule was evaluated based on that distance.

RESULTS AND DISCUSSION

Design of Business Process Modeling

In this discussion, solutions from research objectives to design business process models in rice flour

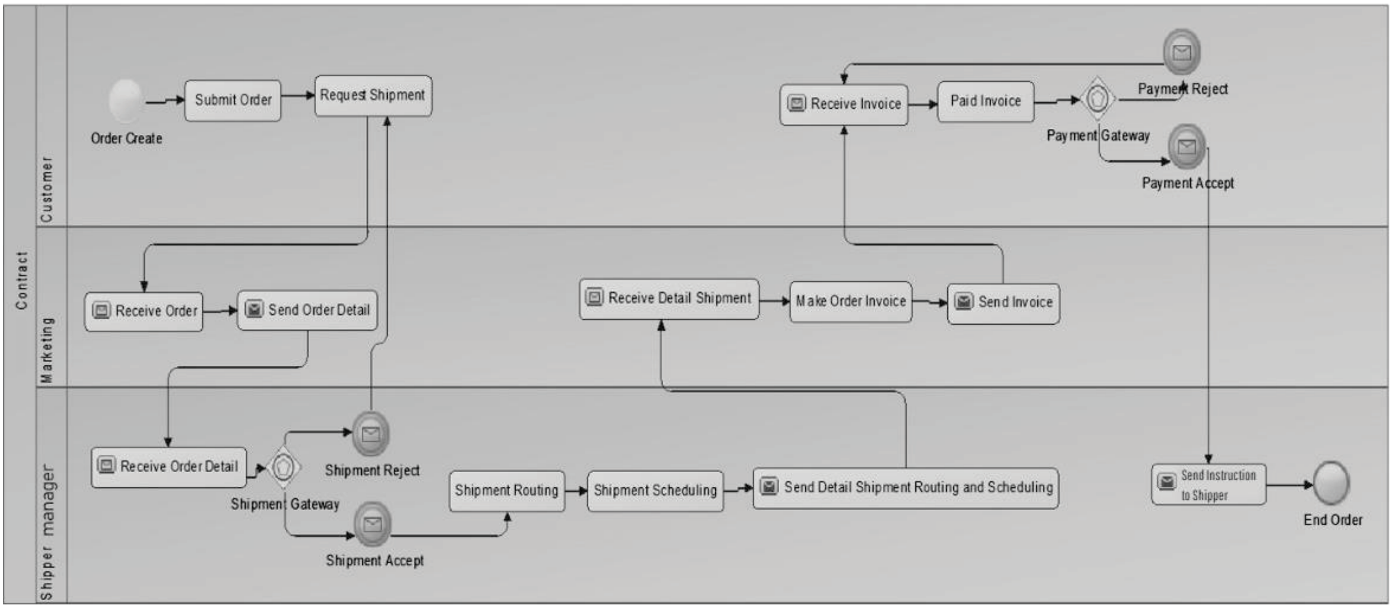

Figure 2. BPMN shipment and invoicing

shipping and invoicing supply chains were explored, and the business process, using blockchain, was modified from previous work of Rocha & Ducasse (2018). Figure 2 describes the flow of the BPMN delivery process and invoicing with the contract for the supply chain of rice flour. The business processes showed that three actors play a role in shipment planning and invoicing, which includes the shipper manager, marketing, and customer.

The first stage originates from the customer when an order is placed, then the marketing process begins upon receipt of the order, which is marked with the order data. The marketing department forwards the order details to the shipper manager and then carries out the shipment procedure through routing and scheduling using the saving matrix method, and the results are then communicated back to the marketing department, which generates an invoice for the customer, serving as the contract. Once the customer made the payment, the shipper manager sends instructions to the sipper for execution.

Minimizing Distance and Delay in Routing and Scheduling

The hypothetical data was used to determine customer location, and the results of the saving method are explained as follows:

(1) Determining the distance matrix

First, the location coordinates of the customer were compared to the delivery location. In this case, the shipment was carried out through a factory warehouse located within the factory. The customer location is explained in Table 1, and the negative value indicates a position on the left side of the x-axis and below the y-axis.

Table 1. Customer location

Code	Customer	Coordinates	
		X	Y
C1	A	120	47
C2	B	66	19
C3	C	-26	-78
C4	D	16	-49
C5	E	-23	-29
C6	F	72	-44
C7	G	-41	18
C8	H	73	33
C9	I	52	-81
C10	J	22	90

Example of calculating the distance between C1 and C2 (J(1.2)):

$$J(1.2) = \sqrt{(120-60)^2 + (47-19)^2}$$

$$J(1.2) = 60.83$$

Table 2 shows the results of distance calculations. C0 is the warehouse location, with coordinates 0,0.

Table 2. The distance matrix (C0-C10)

	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C0	0										
C1	128.88	0									
C2	68.68	60.83	0								
C3	82.22	192.20	133.69	0							
C4	51.55	141.53	84.40	51.04	0						
C5	37.01	161.94	101.12	49.09	43.83	0					
C6	84.38	102.88	63.29	103.73	56.22	96.18	0				
C7	44.78	163.59	107.00	97.16	87.97	50.33	128.89	0			
C8	80.11	49.04	15.65	148.73	99.86	114.28	77.01	114.98	0		
C9	96.25	144.94	100.98	78.06	48.17	91.26	42.06	135.83	115.92	0	
C10	92.65	107.02	83.53	174.72	139.13	127.22	143.02	95.67	76.49	173.61	0

Table 3. The saving matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	0									
C2	136.73	0								
C3	18.89	17.21	0							
C4	38.89	35.82	82.73	0						
C5	3.95	4.58	70.14	44.73	0					
C6	110.37	89.78	62.87	79.70	25.22	0				
C7	10.06	6.45	29.83	8.36	31.46	0.27	0			
C8	159.95	133.14	13.60	31.79	2.85	87.49	9.91	0		
C9	80.19	63.96	100.42	99.63	42.01	138.58	5.20	60.45	0	
C10	114.51	77.80	0.15	5.07	2.44	34.01	41.76	96.28	15.29	0

(2) Calculating the serving matrix

The serving matrix was calculated using data from the distance matrix, and below is an example of serving matrix calculation:

$$S(1.2) = J(0.1) + J(0.2) - (1.2)$$
$$S(1.2) = 128.88 + 68.68 - 60.83$$
$$S(1.2) = 136.73$$

Table 3 shows the details of the serving matrix.

(3) Allocating each point of location to the route

Every customer was allocated to the delivery route, this stage required information on each customer's demand and the availability of company vehicles. Table 4 shows the customer demand, every vehicle had 360 wooden boxes, and each packet weighed 20 kg. Below is the hypothetic number constructed.

Customer pairs were sorted to calculate the saving value before entering the details into the delivery route. This stage used the results from the saving matrix, sorted from the customer pair with the highest saving value to the lowest. Table 5 shows customer pair results for saving value for the top 10 with the highest value.

The most significant customer pair value saving would be placed as the first route in the delivery route and followed by the order of saving value from the largest to the smallest value. This determination process was carried out continuously until a delivery route was generated for each vehicle, and the route determination was forbidden to exceed vehicle capacity. In this research, 360 boxes

Table 4. The customer demands

Code	Customer	Total Demand (Box)
C1	A	131
C2	B	91
C3	C	97
C4	D	114
C5	E	73
C6	F	138
C7	G	131
C8	H	87
C9	I	108
C10	J	96

Table 5. Customer pair for saving value

Cus1	Cus2	Saving matrix
C1	C8	159.95
C6	C9	138.58
C1	C2	136.73
C2	C8	133.14
C1	C10	114.51
C1	C6	110.37
C3	C9	100.42
C4	C9	99.63
C8	C10	96.28
C2	C6	89.78

were assigned for the maximum capacity of each vehicle, and four trucks were used for delivery. Table 6 shows the results of the delivery routing cluster, which covered all of the customer locations.

(4) Sorting point of location for each route

In this stage, the sequence of routes within each customer cluster was established, with the first-served customer being the one closest to the warehouse in terms of distance, and this procedure was carried out using the nearest neighbour. The data used was obtained from the distance matrix, and the nearest neighbour procedural steps are explained in Table 7 below and Table 8 shows the changing of the route.

Table 6. The delivery routing

Route	Vehicle	Customer cluster	Amount of delivery (box)
1	Truck 1	C1-C8-C6	356
2	Truck 2	C9-C2-C10	295
3	Truck 3	C3-C4-C5	284
4	Truck 4	C7	131

Table 7. Detail procedure nearest neighbour for route 1

Iteration	Route	Distance (km)
1	C0-C1	128.88
	C0-C8	**80.11**
	C0-C6	84.38
2	**C8-C1**	**49.04**
	C8-C6	77.01
3	**C1-C6**	**102.88**
4	**C6-C0**	**84.38**
Total		**316.42**

(5) Determining delivery schedule

After getting the route for each truck, the delivery schedule for each truck was determined. It was assumed that there were no constraints from the environment, thereby the speed of truck transport averaged 62 km/

Table 8. The new delivery routes

Route	Vehicle	Customer cluster	Amount of delivery (box)	Distance (km)
1	Truck 1	C0-C8-C1-C6-C0	356	316.42
2	Truck 2	C0-C2-C10-C9-C0	295	422.08
3	Truck 3	C0-C5-C4-C3-C0	284	214.1
4	Truck 4	C0-C7-C0	131	89.56

Table 9. Schedule for delivery route

Route	Vehicle	Customer cluster	Distance (km)	Time (hour)
1	Truck 1	C0-C8-C1-C6-C0	316.42	5.10
2	Truck 2	C0-C2-C10-C9-C0	422.08	8.60
3	Truck 3	C0-C5-C4-C3-C0	214.10	3.45
4	Truck 4	C0-C7-C0	89.56	1.44

hr. This data was obtained from research by Mauliza et al. (2019) where they counted the average truck speed observed on the Cipularang toll road. From data speed, the travel time was calculated with the speed formula according to Equation 3, where t = time, s = distance, and v = speed.

$$t = \frac{s}{v} \qquad (3)$$

Table 9 shows the distance and time disparity between all routes, and this occurred because of the different routes for all vehicles. Route 2 had the highest time and distance, whereas Route 4 had the lowest. This difference occurred because route 2 involved shipping to three customers, resulting in the highest cumulative distance. However, despite this, route 2 also had the highest saving matrix value, while route 4 had the lowest distance as it only delivered goods to one customer.

Invoicing with Contract

Based on design the business processes and shipment planning, the third objective in this research was integrating these results into an invoicing equipped with a contract. Figure 3 shows the prototype design of the platform that provided an invoicing system with the contract.

Figure 3. Platform invoicing with contract

In the invoicing contract, the customer waits for product delivery after making a payment. Additionally, the customer can track which truck transported the order. The customer also noticed the order delivery route—the agreement in the contract guaranteed customer trust, and the order was delivered after the payment. If the demand exceeds the scheduled time, the cost will automatically be returned to the customer.

CONCLUSION

In conclusion, the rice flour supply chain shipment and invoicing business process had three essential actors. This included the shipper manager who played an essential role in compiling shipment planning, calculating the route and scheduling; marketing which was responsible for generating invoices; and the customer, who placed orders and paid the billed invoices. These actors and their roles were recommended for the design contract model in the rice flour supply chain. The contract was entered into the invoice based on the results of routing and scheduling using the saving matrix. This provided the customers with trust, as well as a guarantee in the form of a contract. Upon payment for the products, customers received the orders, with the assurance that their money would be automatically refunded if the orders were not received according to the delivery schedule.

LIMITATION

This research did not cover the effectiveness of the supply chain business process design and focused on the design business process (actors and their role in shipment planning, routing, scheduling, and invoicing). It recommended the saving matrix method to do the shipment routing and scheduling. Furthermore, this research could continue with calculating the effectiveness of the supply chain design.

CONFLICT OF INTEREST

All the authors state that they have no conflicts of interest with any party in this article.

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