

## Research Article

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# Supply chain efficiency of red chili based on the performance measurement system in Yogyakarta, Indonesia

<https://doi.org/10.1515/opag-2021-0224>

received October 16, 2020; accepted January 5, 2021

**Abstract:** This study aimed to describe the relationship structure of the red chili supply chain based on actors and their activities and to measure the efficiency of the red chili supply chain using the Performance Measuring System (PMS) framework. The distribution of the red chili supply chain in this study began with farmers in Kulon Progo, Yogyakarta, and extended to consumers in Jakarta, Indonesia. The sampling technique was carried out in several stages for 132 respondents consisting of red chili farmers and consumers. The supply chain relationship structure was analyzed descriptively, while the efficiency of the red chili supply chain was examined using the PMS framework, including indicators of production costs, transaction costs, profits, and return on investment. The results revealed that the relationship structure of the red chili supply chain was formed by three chains consisting of eight actors: farmers, middlemen, wholesalers at the regency level, auction markets, Kramat Jati Central Market or Pasar Induk Kramat Jati (PIKJ) dealers, PIKJ *centeng*, retailers, and consumers. According to production costs, transaction costs, profits, and the rate of return on investment, chain three was the most efficient with chain actors comprising farmers – auction markets – wholesalers at the regency level – PIKJ dealers – PIKJ *centeng* – retailers – consumers.

**Keywords:** efficiency, supply chain, performance measurement system, red chili

## 1 Introduction

Indonesia is well-known not only as a significant agrarian country, but also as the largest archipelago in the world. To build its national economy, priority of place has been given to the agricultural sector (Hamilton-Hart 2019). This strategic position of agriculture *vis-à-vis* the national economy (Morley et al. 2019) translates into its primacy in development efforts, its role as a source of national income, and its contribution to poverty reduction (Libin 2018).

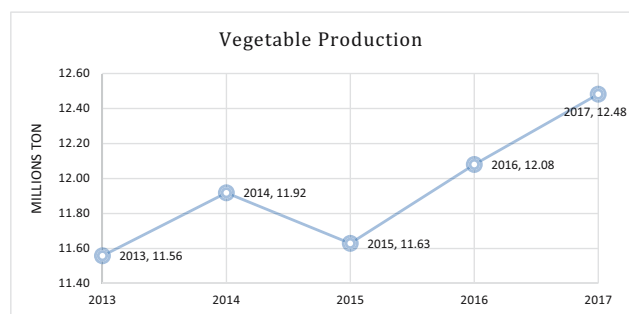
One of the subsectors of agricultural development consists of horticultural crops. Horticulture comprises several types of potential commodities such as vegetables, fruits, ornamental plants, and biopharmaceuticals. An increase in Indonesian vegetable production occurred in 2013–2017, and as depicted in Figure 1, this increase was most pronounced in 2015–2016, at 3.87%.

With regard to particular vegetable crops, Indonesian consumers are very fond of chilies (*Capsicum annum* L.), and they use them as a complementary ingredient in many of their dishes (Zamrodah and Pintakami 2020). Chilies can thus be seen as an important commodity favored by consumers which meets their household needs (Amaral et al. 2019). Additionally, chilies are used as raw material in the chili processing and medicine or herbal medicine industries. In general, chilies contain many nutrients and vitamins, including calories, protein, fat, carbohydrates, calcium, vitamin A, vitamin B1, and vitamin C (Karyani et al. 2020).

Although chili is not a staple food, its high consumption in Indonesia, given its use in daily cooking, indicates that it is a high demand commodity. Gaging the relationship between consumer demand and availability, the price of chilies is likely to fluctuate and thereby impact the national economy (Chen Van et al. 2017). Table 1 presents the development of chili consumption data in Indonesia in 2010–2014. It signifies that the development of chili consumption had an average growth rate of 20% per year.

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**Figure 1:** Trend of vegetable production in Indonesia in 2013–2017. Source: Ministry of Agriculture Republic Indonesia (2018).

**Table 1:** Development of chili consumption in Indonesia (2010–2014)

Types of chili	Consumption (kg/Capita/Year)					Total
	2010	2011	2012	2013	2014	
Red chili pepper	1.528	1.497	1.653	1.424	1.460	7.562
Green chili	0.256	0.261	0.214	0.198	0.214	1.143
Cayenne pepper	1.298	1.210	1.403	1.272	1.262	6.445
Total	3.082	2.968	3.270	2.894	2.936	15.150

Source: Ministry of Agriculture (2015).

Red chilies are one of the major agricultural products in the Special Region of Yogyakarta. As presented in Table 2, from 2014 to 2017, the harvested area for chili pepper in this region displayed an upward trend; more specifically, it decreased by 0.85% from 2014 to 2015 and increased from 2016 to 2017.

We chose to investigate red chili because of its high demand, high selling price, and good market prospects, as evidenced by consumer interest and yearly price increases. In addition, it has a reasonably good marketing area and can be planted in various environments such as coastal areas, medium plains, and highlands (Romeida et al. 2020). National red chili production during 2006–2015 contributed an average of 50.79% per year,

**Table 2:** Harvested area of seasonal vegetable plants by plant type in the Special Region of Yogyakarta (2014–2017) (in hectares)

No	Types of plants	Year			
		2014	2015	2016	2017
1	Chili pepper	2,791	2,767	3,376	3,581
2	Cayenne pepper	1,256	925	1,072	1,353

Source: Statistics of D.I. Yogyakarta (2017).

while production outside of Java contributed 43.21% (Yanuarti and Afsari 2016).

One of the red chili production base areas in Java Island is the Special Region of Yogyakarta (DIY). There are four red chili producing regencies in DIY: Kulon Progo, Sleman, Bantul, and Gunungkidul, which are presented in Table 3. This table shows that the highest red chili productivity was in Kulon Progo, with an average productivity of 9 tons/hectare.

Kulon Progo Regency as a center for red chili production not only meets the needs of the region, but also outside areas such as Jakarta, Malang, Surabaya, and Lampung. The process of red chili distribution to consumers is inseparable from the supply chain concept. More specifically, the supply chain covers all interactions between suppliers, manufacturers, distributors, and customers (Yildiz and Ahi 2020). This interaction among stakeholders is managed in order to achieve a sustainable supply chain (Giacomarra et al. 2019) and provide a value creation (Pucci et al. 2018). Moreover, a supply chain can be defined as the set of relationships between companies or activities which carry out the distribution of the supply of goods or services from the place of origin to the place of the buyer or customers (Assauri 2011). In the horizontal perspective, there are five major actors in the supply chain: supplier, manufacturer, wholesaler, retailer, and customer (Sunny et al. 2020). In the vertical perspective, there are five major components of the supply chain: buyer, carrier, warehouses (storage), customer, and seller.

The supply chain evolves in three parts (Anatan 2010), namely, the upstream supply chain, the internal supply chain, and the downstream supply chain. Chopra and Meidl (2004) claim that the supply chain is dynamic and covers the flow of information, products, and money at the supply chain level. Moreover, a supply chain consists of parties involved either directly or indirectly in response to customers, and these parties include manufacturing, suppliers, transportation, warehouses,

**Table 3:** Development of red chili production in DIY (2011–2015) (in tons)

Regency	Year				
	2011	2012	2013	2014	2015
Kulon Progo	10,722.6	11,581.6	10,920.8	12,507.5	16,828.0
Sleman	2,785.5	2,859.9	4,193.8	3,615.7	4,430.7
Bantul	525.1	1,670.2	1,765.1	1,224.4	1,969.3
Gunungkidul	336.9	345.3	253.8	253.8	159.9
<b>DIY</b>	<b>14,370.1</b>	<b>16,457.0</b>	<b>17,133.5</b>	<b>17,601.4</b>	<b>23,387.9</b>

Source: Statistics of D.I. Yogyakarta (2016).

retailers, and customers. Meanwhile, Vorst (2004) explains that the supply chain constitutes several physical activities and decision-making processes related to the flow of substances, information, and money. Physical flow concerns the movement of products from supplier to customer, while information flow concerns the number of requests, supply chain network coordination, delivery status, and payment information (Athaillah and Hamid 2018). Financial flow includes cash and credit payments and payment schedules. In the supply chain itself, the meaning of the flow of material from the beginning to the consumer takes into account the factors of timeliness, cost, and number of products (Aquilano 2006).

The majority of supply chain guides build their conceptual framework around the notions of chain governance and upgrading (Springer-Heinze 2007; Webber and Labaste 2009; Devaux *et al.* 2016). The food supply chain, in particular, would implement effective practices that improve the state of sustainable food security, such as food security governance involvement, input resource management, output management, and information sharing. The success of the food supply chain depends on the strong and effective interaction among stakeholders (Fiore *et al.* 2020), including the raw materials supplier, the packaging provider, repackers, printing companies, intermediary traders, and other suppliers (Djuric and Götz 2016; Pujawan and Mahendrawathi 2017). Notably, the typical characteristics of agricultural products cause the complexity of supply chain problems to increase (Soepatini *et al.* 2018). For instance, supply chain stakeholders, mainly small and marginal farmers, receive a very minimal share in consumer rupee due to market uncertainty, high postharvest losses, information asymmetry, a lack of processing facilities, and an erratic demand-supply situation. The logistics systems of agricultural products possess certain specific characteristics and therefore require specific and different handling methods as well, given that they are affected by production systems, the nature of the product, and the consumers themselves (Yun and Kurniawan 2015). Thus, the process in a supply chain – from the farmer to the consumer – determines its efficiency (Solekhah and Aspiranti 2018).

While red chili is a commodity with high economic value, at the same time, it carries a risk: there may be price fluctuations because of an unstable supply, counterbalanced with high consumer demand (Karyani *et al.* 2020). This demand will likely continue to increase as the population itself increases (Suwarsinah *et al.* 2018). As prices relative to each actor usually differ according to their respective interests, the costs of production and transactions will be affected and ultimately impact the profit earned by the actor. Profit is an indicator of measuring the efficiency of a

supply chain, including the red chili commodity. Moreover, the measurement of supply chain performance efficiency plays an important role in determining the condition of a company (Pohlmann *et al.* 2020), whether it has decreased or increased in scope and productivity, and what improvements should be made to improve the company's performance (Sufa *et al.* 2016). In addition, inefficiency is another issue in the food supply chain for commodities such as red chili (Kamble *et al.* 2020). Therefore, it is necessary to conduct a study to describe the relationship structure of the red chili supply chain in terms of actors and activities, and the efficiency of the supply chain based on the performance measurement system (PMS) framework, viewed from the perspective of production costs, transaction costs, profits, and investment returns.

## 2 Research method

This research employed a descriptive method that systematically describes, actually and accurately, the factors, properties, and relationships between the phenomena in the study (Sugiyono 2017). This method facilitated a study of the efficiency of the red chili supply chain by describing the analysis results. The research location in Kulon Progo Regency, Indonesia, was selected because the region is a red chili production center in the Special Region of Yogyakarta, as presented in Table 3. The sampling of this study was carried out through the following stages:

1. The first stage was determining the district. Research was purposively carried out in Panjatan District, since it has the highest rate of red chili production compared to the other 11 districts in Kulon Progo Regency, namely, 10565.3 tons in 2018, as presented in Table 4.
2. The second stage was village sampling. From the selected district, namely Panjatan District, three villages possessed auction markets for red chilies, namely Bugel, Garongan, and Pleret, as shown in Table 5. Out of the three villages, Garongan was selected, as it had the most auction market members.
3. The third stage was determining the farmer groups in Garongan Village. A total of 285 farmers registered as members of the auction markets in Garongan Village, who came from three farmer groups: Bangunkaryo, Jangkang Wetan 1, Jangkang Wetan 2, and Ngudi Hasil, each in sequences of 115, 100, and 70 farmers, respectively. At the time of the research, there were only two farmer groups whose auction markets were active, namely, Bangunkaryo and Ngudi Hasil. Of the 115 farmers in the Bangunkaryo farmer group, only 60 were active, while in the Ngudi Hasil farmer group,

**Table 4:** Red chili production in Kulon Progo (2018)

No	Districts	2018 production (ton)
1	Temon	4,299.9
2	Wates	5,972.9
3	Panjatan	10,565.3
4	Galur	2,377.4
5	Lendah	1,077.7
6	Sentolo	252.1
7	Pengasih	425.3
8	Kokap	194.6
9	Girimulyo	62.6
10	Nanggulan	15.4
11	Kalibawang	173.0
12	Samigaluh	26.6
<b>Total</b>		<b>25,442.8</b>

Source: Agriculture Office of Kulon Progo Regency (2019).

**Table 5:** Number of auction markets and the members in Panjatan District, Kulon Progo Regency (2019)

Village	Number of auction markets	Auction market members
Bojong	—	—
Bugel	2	170
Cerme	—	—
Depok	—	—
Garongan	4	285
Gotakan	—	—
Kanoman	—	—
Krembangan	—	—
Panjatan	—	—
Pleret	2	100
Tayuban	—	—

Source: Bangunkaryo Farmer Group (2019).

- only 20 farmers planted red chilies during the research. Hence, the number of farmers sampled was 80 people.
- The fourth stage was determining the respondents of red chili supply chain actors, other than farmers, using snowball sampling. Snowball sampling techniques are a method of identifying, selecting, and sampling in a continuous network or chain of relationships (Nurdiani 2014). The respondents consisted of two middlemen in Garongan Village, the Head of the Auction Market Management, two collecting traders at the Kulon Progo Regency level, three dealers at Kramat Jati Central Market in Jakarta or Pasar Induk Kramat Jati (PIKJ), ten PIKJ *centeng* (a person taking merchandise from a dealer and having a narrow and sometimes non-permanent place to sell), 20 retailers in Jakarta, and 30 consumers who were also in Jakarta.

Moreover, the data used in this study were primary data that included supply chain actors' activities, explicit costs, implicit costs, fixed costs, variable costs, total production costs, transaction costs, investment costs, negotiation costs, market search costs, red chili production, red chili prices, red chili discounted prices in the auction market, and revenue. The data were collected via interviews with the help of a questionnaire for all actors in the red chili supply chain.

Descriptive analysis in the form of a chart was employed to explain the red chili supply chain relationship. The chart depicted the number of chains and actors making up the supply chain structure. Apart from being in chart form, descriptive analysis in table form was also required to explain each actor's activities within the relationship structure of the red chili supply chain. The supply chain efficiency of red chili was analyzed based on the PMS framework, which consisted of five indicators: production costs, transaction costs, profits, inventory costs, and return on investment (ROI). The red chili commodity was in fresh form, thus causing the supply indicator to be excluded in this study. Many studies have identified the supply chain management (SCM) components that need to be addressed by the organizations, with Beamon (1999) in particular stating that a PMS framework is important to an effective performance measurement in SCM. In order for PMS to be appropriately structured, it must provide managers with easily accessible and comprehensible information (Morgan 2004). As an essential management technique, PMS provides the assistance need to improve supply chain achievement and increase overall customer satisfaction, the level of competitiveness, and a firm's profitability (Ahmad and Zabri 2018).

**Informed consent:** Informed consent has been obtained from all individuals included in this study.

**Ethical approval:** The institutional review board of the Universitas Muhammadiyah Yogyakarta indicated that the present study was exempt from a full review because there was minimal risk to participants.

## 3 Results and discussion

### 3.1 Relationship structure of the red chili supply chain

The relationship structure of the red chili supply chain was viewed from the perspective of the actors forming the

supply chain and the activities of each of these actors. “Actors” referred to the institutions or actors involved in the flow of products, information, and money, starting with the red chili farmers in Panjatan District, and ending with the final consumers in Jakarta. The relationship structure of the red chili supply chain in Yogyakarta was formed by three chains consisting of eight actors: farmers, auction markets, middlemen, wholesalers at the regency level, Kramat Jati Central Market or PIKJ dealers, PIKJ *centeng*, retailers, and consumers. PIKJ *centeng* is a wholesaler who buys chilies in bulk from PIKJ dealers and then sells them to retailers in smaller quantities (Yuliarti and Fitriani 2011). The minimum amount of chili purchases from PIKJ *centeng* by retailers is 50 kg.

Theoretically, there are four main actors in the food supply chain: manufacturers, suppliers, logistics service providers, and retailers (Manders et al. 2016). Moreover, this study found that there were several actors in the relationship structure of the red chili supply chain in Yogyakarta, as illustrated in Figure 2. Based on Figure 2, the farmer is the manufacturer or producer of red chili, while auction markets, middlemen, collecting traders, and PIKJ dealers act as suppliers. Suppliers play an important role in the food supply chain as both trader and supplier to multiple channels (Perdana et al. 2018).

Each red chili supply chain actor in the relationship structure played a different role, as shown by the activities they carried out, which in turn contributed to a well-run supply chain. More specifically, the activities of the

red chili supply chain actors in Panjatan District, Kulon Progo Regency, are presented in Table 6.

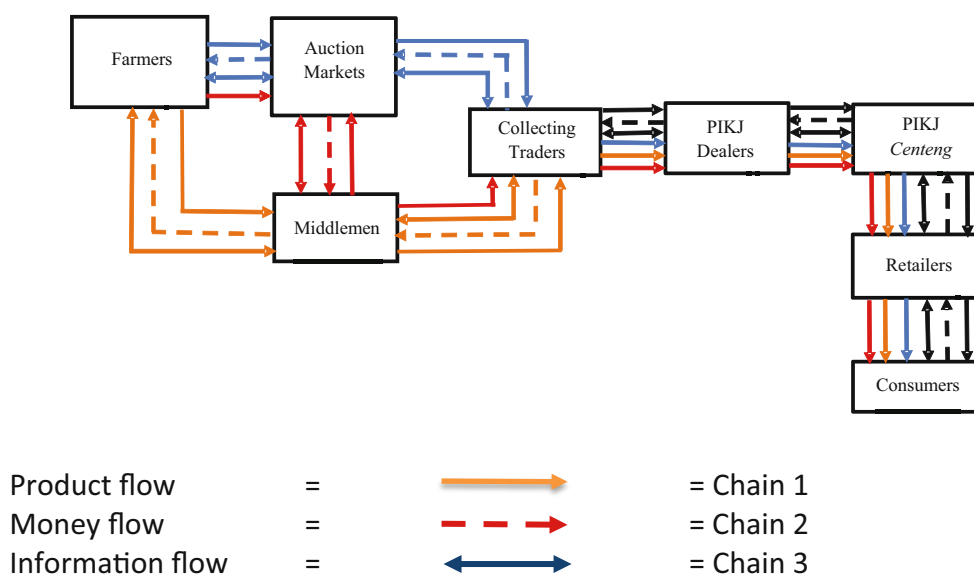
Based on Table 6, packaging, pricing, and purchasing were the most numerous activities carried out by the majority of supply chain actors. Moreover, collecting traders and *centeng* at PIKJ market were the actors who were most involved in many red chili supply chain activities.

### 3.2 Red chili supply chain efficiency

Efficiency is one of the supply chain performance indicators based on the PMS framework in terms of responsibility, flexibility, and food quality. There are also several sub-indicators that measure supply chain efficiency, including production costs, transaction costs (Aramyan 2007), profits, and ROI (Stranieri et al. 2021).

#### 3.2.1 Production cost

Production costs are incurred by supply chain actors during the production process on land or in the process of buying and selling red chili for actors other than farmers. Production costs at the farm level consist of explicit and implicit costs. As for actors other than farmers, the concept of production costs applies fixed and variable costs.



**Figure 2:** Relationship structure of the red chili supply chain in Panjatan District, Kulon Progo Regency, Yogyakarta.



**Table 6:** Activities of red chili supply chain actors in Kulon Progo Regency

No	Activities	Actors							
		Farmers	Middlemen	Auction markets	Collecting traders	Dealers	Centeng	Retailers	Consumers
1	Red chili farming	✓							
2	Sorting	✓	✓	✓	✓				
3	Packaging		✓	✓	✓		✓	✓	
4	Pricing		✓		✓	✓	✓	✓	
5	Bid					✓	✓	✓	✓
6	Updating information		✓	✓	✓	✓	✓		
7	Purchasing red chilies		✓		✓	✓	✓	✓	✓
8	Transporting				✓				
9	Delivery of red chilies				✓				
10	Receiving payment		✓	✓	✓	✓	✓	✓	
11	Sales					✓	✓	✓	
12	Cleaning and separating the red chilies					✓	✓	✓	✓

**Table 7:** Production costs of red chili supply chain actors during one planting season (May–July 2019)

Supply chain actors	Value (IDR)	Percentage
Farmers	49,348,527	22.95
Auction markets	31,787,000	14.78
Middleman	1,464,367	0.68
Wholesalers at regency level	38,138,375	17.74
PIKJ Dealers	62,471,500	29.06
PIKJ Centeng	27,216,565	12.66
Retailers	4,579,200	2.13
<b>Total</b>	<b>215,005,534</b>	<b>100</b>

PIKJ dealers issued the highest production cost of IDR 62,471,500, used for the entire process of selling red chilies (Table 7). The high production cost incurred by dealers may be because of the risks they bear in the supply chain, such as the risk of decreasing product quality (Kurniawan et al. 2019). Middlemen incurred the lowest cost of IDR 1,464,367, which was due to the fact that the red chilies they sold were not as numerous as those in the auction markets, thereby causing the least costs incurred to sell chilies.

### 3.2.2 Transaction fees

Transaction aspects are one of the most widely referenced organizational theories in operations and supply chain management research (Ketokivi and Mahoney 2020). Transaction fees are charges other than those incurred in trading red chilies, consisting of market search,

implementation, and negotiation costs. Market search costs were used to obtain information about buying and selling opportunities for red chilies, negotiation costs were incurred for an exchange under negotiation, and contract implementation costs were incurred in executing the contract (Table 8).

Transaction fees for farmers solely consisted of discounted fees for auction market cash, agreed to by all farmers within the farmer group and auction market administrators. The discount was based on the chili price in multiples of five, as depicted in Table 9.

Dealers incurred a negotiation fee of IDR 32,067 for the exchange or transaction process after negotiation (Table 8).

**Table 8:** Transaction costs of red chili supply chain actors during one planting season (May–July 2019)

Supply chain actors	Transaction fee (IDR)		
	Implementation cost	Negotiation fee	Market search costs
Farmers	—	1,838,386	—
Auction markets	—	—	—
Middleman	—	—	—
Kulon Progo wholesalers	—	—	—
PIKJ Dealers	—	32,067	—
PIKJ Centeng	—	42,314	—
Retailers	—	56,600	—
Consumers	—	1,495,500	708,000
<b>Total</b>	<b>—</b>	<b>3,432,800</b>	<b>708,000</b>

**Table 9:** Discounts on red chili

The price of chili (IDR) per kg	Discount (IDR)
5,000	100
10,000	200
15,000	300
20,000	400
25,000	500
30,000	600
35,000	700
40,000	800
45,000	900
50,000	1,000
55,000	1,100
60,000	1,200
65,000	1,300

This negotiation process was carried out between the dealers and the *centeng* in PIKJ to reach an agreement on the exchange or transaction of red chili. The PIKJ *centeng* employed a delay system in the payment process, thereby agreeing to negotiate returns. PIKJ *centeng* would pay for the red chilies after receiving money from sales to retailers. Retailers paid a negotiation fee of IDR 56,600. This fee arose when a transaction between a *centeng* and a retailer reached an agreement on an exchange or transaction of red chili. Retailers made cash payments, thus causing no delay in payments. Moreover, in order to increase supply chain efficiency, the red chili supply chain should decrease transaction fees. Accordingly, information technology can be used to facilitate the transaction process so as to reduce transaction costs (Kamilaris *et al.* 2019).

### 3.2.3 Profit

Profits were derived by subtracting total expenses from total income. Income from supply chain actors was obtained from the multiplication of the sales and selling price of red chilies, and profits would affect the return on investment for each supply chain actor. The income and profits of supply chain actors are discussed below.

The supply chain actor with the highest profit was the wholesalers at the regency level, with IDR 298,611,625, because the income of the PIKJ dealers was higher than the total cost incurred (Table 10). Conversely, the lowest profit was for retailers, with IDR 3,441,050, since they did not only sell chilies, but also vegetables and other spices. Hence, their profits were not only from selling red chilies. Supply chain actors profit could be increased by improving the coordinated supply chain and government

**Table 10:** Income and profits of red chili supply chain actors during one planting season (May–July 2019)

Supply chain actors	Income (IDR)	Profits (IDR)
Farmers	123,549,064	74,200,537
Auction markets	52,602,372	20,815,372
Middleman	12,715,000	11,250,633
Wholesalers at the regency level	336,750,000	298,611,625
PIKJ dealers	34,600,000	283,528,500
PIKJ <i>Centeng</i>	40,021,429	12,804,864
Retailers	8,020,250	3,441,050
<b>Total</b>	<b>919,658,115</b>	<b>704,652,581</b>

incentives such as grants or tax reductions to wholesaler or auction markets (Heydari *et al.* 2017).

### 3.2.4 Return on investment (ROI)

Return on investment, or ROI, is one of the profitability ratios frequently employed to assess an organization's financial performance based on financial reports and company profits (Romadani *et al.* 2016). Similarly, Munawir (2004) mentions that ROI is the ability to generate profits with funds and assets, and according to Hanafi and Mamduh (2010), ROI measurement is an assessment of a company's ability to generate net income based on companies and investors. Syamsudin (2011) states that the higher the ROI value, the better the condition. ROI is considered good if its value is more than zero (Sarsour and Sabri 2020), and bad if it is less than zero or negative. In this red chili supply chain, the ROI measurement was an assessment of the chain actor's ability to generate profits based on the investment issued.

The highest ROI occurred for PIKJ dealers, with a value of 6.8, meaning that one rupiah of capital invested by a PIKJ dealer would generate a 6.8-times return (Table 11).

**Table 11:** ROI of red chili supply chain actors during one planting season (May–July 2019)

Supply chain actors	ROI (%)
Farmers	2.4
Auction markets	1.2
Middleman	1.1
Wholesalers at regency level	2.0
PIKJ dealers	6.8
PIKJ <i>Centeng</i>	1.4
Retailers	1.4
<b>Total</b>	<b>16.3</b>

Table 12: The efficiency of red chili supply chain during one planting season (May–July 2019)

Indicator	Farmers	Middlemen	Collecting traders	PIKJ dealers	PIKJ Centeng	Retailers	Consumers	Total
Chain 1								
Production costs	7,908,044	1,464,367	38,138,375	62,471,500	27,216,565	4,579,200	—	141,778,051
Profits	12,168,679	11,250,633	298,611,625	283,528,500	12,804,864	2,393,550	—	620,757,851
Return on investment	1.4	1.1	2.0	6.8	1.4	1.4	—	14.1
Transaction fees	—	—	—	32,067	42,314	56,600	2,203,500	2,334,481
Chain 2								
Production costs	7,908,044	1,464,367	31,787,000	38,138,375	62,471,500	27,216,565	4,579,200	—
Profits	12,168,679	11,250,633	20,815,372	298,611,625	283,528,500	12,804,864	2,393,550	—
Return on investment	1.4	1.1	1.2	2.0	6.8	1.4	1.4	—
Transaction fees	—	—	—	—	32,067	42,314	56,600	2,203,500
Chain 3								
Production costs	8,664,886	31,787,000	38,138,375	62,471,500	27,216,565	4,579,200	—	172,857,526
Profits	74,884,178	20,815,372	298,611,625	283,528,500	12,804,864	2,393,550	—	693,038,089
Return on investment	8.8	1.2	2.0	6.8	1.4	1.4	—	21.6
Transaction fees	—	—	—	32,067	42,314	56,600	2,203,500	2,334,481

In other words, the red chili business carried out by the PIKJ dealer was profitable. Conversely, the lowest ROI was for the middlemen at 1.1, as they did not sell many red chilies and thus earned a smaller profit.

To measure the efficiency of the red chili supply chain, it is necessary to look at the indicators of production costs, transaction costs, profits, and ROI. The efficiency of the complete three chains is presented as follows.

Table 12 illustrates that the lowest production costs occurred in chain 1, while the highest was in chain 2. The highest profit was in chain 3, and the lowest occurred in chain 1. The best rate of ROI occurred in chain 3, and the lowest was in chain 1. The value of transaction costs was the same for all three chains, thereby determining that the efficiency of the red chili supply chain was merely viewed from 3 indicators comprising production costs, profits, and the rate of ROI. Based on the three indicators, the most efficient red chili supply chain occurred in chain 3 because both profits and ROI achieved the highest result, followed by chain 2 and chain 1. With ROI analysis, it can be seen which chain is the most efficient in terms of investment, so that it can be used to reduce investment costs in the supply chain (Rahayu et al. 2020).

## 4 Conclusions and recommendations

This study sought to examine the relationship structure of the red chili supply chain in Yogyakarta, Indonesia. There were three chains and eight actors on the red chili supply, namely: (1) Farmers – Middlemen – Wholesalers at the Regency Level – PIKJ Dealers – PIKJ Centeng – Retailers – Consumers; (2) Farmers – Middlemen – Auction Markets – Wholesalers at the Regency Level – PIKJ Dealers – PIKJ Centeng – Retailers – Consumers; and (3) Farmers – Auction Markets – Wholesalers at the Regency Level – PIKJ Dealers – PIKJ Centeng – Retailers – Consumers. Based on the indicators of production costs, transaction costs, profits, and the rate of ROI, chain 3 was the most efficient, as it produced the most massive profit and ROI, followed by chain 2 and chain 1. Moreover, the distribution of red chili from farmers directly to the auction markets in chain 3 also contributed to the red chili supply chain's efficiency.

The findings of this study may provide implications from both theoretical and practical perspectives. Theoretically, it contributes to the supply chain efficiency theory of food products with fluctuating prices such as chili.



From a practical point of view, this study provides useful recommendations for stakeholders in the chili supply chain, such as farmer groups and governments, to optimize and increase the role of the auction market in the chili supply chain. Moreover, the limitation of this study is the scope of the sample, which is only one major producer of chili in Indonesia. Future research should consider and possibly compare these findings with the aspects of another chili production center in Indonesia in order to obtain the broader perspective of red chili supply chain behavior.

**Acknowledgments:** This research has been financially supported by Ministry of Research and Technology/ National Research and Innovation Agency Republic of Indonesia, Deputy for Strengthening Research and Development, under research grants of the Higher Education Leading Basic Research (PDUPT) scheme No. 277/SP2H/AMD/LT/DRPM/2020.

We also would like to thank Mr. Sudiro as Head of Auction Market Association of Kulon Progo, Indonesia, and member of Auction Market Association of Panjatan District, Kulon Progo, Indonesia, including farmers and traders, for their support and assistance on data collection of red chili supply chain network.

Our sincere thanks also goes to our colleagues from Department of Agribusiness who provided expertise and supported on data collection, although they may not agree with all of the interpretations provided in this paper.

**Funding information:** Research grants of the Higher Education Leading Basic Research (PDUPT) scheme No. 277/SP2H/AMD/LT/DRPM/2020 by Ministry of Research and Technology/National Research and Innovation Agency Republic of Indonesia, Deputy for Strengthening Research and Development.

**Author contribution:** MF: project administration; S: conceptualization, methodology, and writing original draft; ZR: visualization; HA: writing-review and editing.

**Conflict of interest:** The authors state no conflict of interest.

**Data availability statement:** The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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