Measurement of Intermediary Trader Efficiency in Poultry Distribution Using Data Envelopment Analysis Method

R Purwaningsih¹, C G Pratiwi¹, N Susanto¹, and H Santosa¹

¹Industrial Engineering Department, Faculty of Engineering, Diponegoro University Jl. Prof. H. Soedarto, SH. Semarang 50275
ratna.tiundip@gmail.com

Abstract. The in-efficiency in resource usage are still common problems in poultry industry. In-efficiency in operational distribution system made the price of meat were so expensive at end customer. Increased efficiency is needed to improve competition capabilities. This research aims to measure the relative efficiency of intermediary trader in poultry product by using Data Envelopment Analysis (DEA) and formulate recommendation based on result of DEA. The result of data processing shows that 3 of 11 intermediary classified as inefficient group. These intermediary trader group should increase their relative efficiency by aligning the influencing input variable of distribution cost and overhead cost.

1. Introduction
Chicken meat is the most consumed meat by Indonesian people. The opportunity of the poultry industry sector in meeting the needs of the society is wide open. The poultry industry has an important role in driving the national economy. It absorbs Rp 1.68 trillion (60%) from Rp 2.8 trillion investments in the livestock sub-sector [1]. Now days, 90% of chicken product in Indonesia distributed and store using traditional systems which not applied the cold chain and used simple equipment in producing and marketing the product in the traditional market[2]. Other problem in poultry business is a significant price disparity between live bird prices and chicken meat prices. Some stakeholder assumes that the price of chicken meat at end customer has been determined by a cartel of the intermediary trader.

The distribution process give contribution on the formation of selling prices at the consumer level. Good handling of supply chain activities can create added value which profitable and fair for each parties in the chains. The preliminary studies found some inefficient in the use of resources during the distribution process done by intermediary traders. Inefficiencies found on fuel usage (chicken load is too little compared to total truck capacity), water use when turning chicken feathers and workers idle during working hours.

The in-efficiency in the distribution process is a serious problem in livestock agribusiness. This problem contributes to the increasing price of the product at the final consumer level. Achieving high efficiency can increase the competitive level and profit. A research study is needed to find a way to improve traditional distribution in poultry industries. It was necessary to take efficiency measurements on brokers or intermediate trader which played an important role in broiler distribution processes because the most added value in the chicken supply chain was on the intermediary side. The efficient activities on live birds distribution by intermediaries (collectors) will affect the formation of prices at the end-level traders. Therefore, it is necessary to measure the relative efficiency of intermediaries trades (collectors) in order to allocate resources well.
The approach used is Data Envelopment Analysis (DEA), one of the supply chain performance measurement techniques based on linear programming. DEA measure the efficiency of each DMU (single unit of intermediary trader) by comparing value of inputs and outputs. Result of DEA is the relative efficiency of one DMU to other DMU. The relative efficiency value can be used as a tool to formulate recommendations for inefficient DMU by refers to the value of efficient DMU. This research was conducted in Bantul Regency, Yogyakarta province. Yogyakarta is the 5th largest poultry production area in Indonesia.

2. Literature review

2.1. A Broiler Chicken Distribution Chain Model

A distribution channel is a chain of businesses or intermediaries through which a good or service passes until it reaches the final buyer or the end consumer. Distribution channels is a structure of organizational units between companies with agents, wholesaler and retail, or as a group of intermediaries who do the distribution and marketing process from the first owner to the last owner [1]. Based on production capacity and production equipment, there are two main lines on poultry products distribution and marketing Clean Market chain and Wet market chain.

The clean Market chain is a modern market which start from the company farm or big farm to meat processing industries and end to customer as finished products. The distribution and storage of product already use cold chain system that keep the product on a certain temperature to prevent quality decreases. While the traditional market or wet market chain consist of intermediaries (collectors) or distributors, either directly or through brokers, which use simple cooling technology to distribute product at traditional markets to end consumers.

Supply chain actors involved in broiler distribution processes are farm equipment suppliers, breeding farms, poultry feed manufactures, farmers and intermediary traders [3]. Farmers provide an important position to produce live birds ready to be harvested within 35 days. Intermediary traders are actors in distribution and processes live birds to became carcass. Intermediary trader are brokers, collectors, and seller on retail level.

Collectors are a trader who picked up live birds from a farm directly or through a broker, then sale the live birds to seller who sell chicken meat to the end customers. Collectors have a risk of fewer profit causes by postharvest losses during distribution processes. Efficient collectors have a very important position in determining the end price of meat. The DEA method used to measure the efficiency of collectors as one of intermediary traders in a supply chain.

2.2. Data Envelopment analysis

DEA was first developed by Cooper, Charnes and Rhodes (CCR model) as a technical parametric base on linear programming that use to measure the relative effectiveness of a homogenous Decision-Making Unit (DMU) with multiple inputs to produce multiple outputs [4]. To calculate relative effectiveness, DEA model creates virtual input and output for every DMU, where V1 (for input) and U1 (for output) have a variable value character and unknown yet.

Virtual input = \( V_1 X_{10} + V_2 X_{20} + \ldots + V_m X_{m0} \)
Virtual output = \( U_1 Y_{10} + U_2 Y_{20} + \ldots + U_n Y_{n0} \)

Then relative effectiveness from every DMU (decision making unit) can calculate with an efficiency ratio:

\[
\text{Efficiency} = \frac{\text{Virtual output}}{\text{Virtual input}}
\]

\[
H_0 = \frac{\sum_{r=1}^{S} U_r Y_{10}}{\sum_{m=1}^{M} V_m X_{10}}
\]

2
Efficiency = \frac{\text{Virtual output}}{\text{Virtual input}} \quad (3)

H_0 = \frac{\sum_{r=1}^{s} U_r Y_{ro}}{\sum_{i=1}^{m} V_i X_{io}} \quad (4)

Which

s : Sum of output
m : Sum of input
U_r : output value to -r
V_i : input value to-i
X_{io} : Sum input to-i that use by DMU
Y_{ro} : Sum output to-r that result by DMU.

At present, DEA actually encompasses a variety of alternative approaches to performance evaluation. Extensions to the original CCR (cooper, Charnes and Rodhes) work have facilitated a deeper analysis of both the “multiplier side” from the dual model and the “envelopment side” from the primal model of the mathematical duality structure [5]. This research used the CCR model. Other model in DEA is BCC model. BCC more precisely use for services company performance analysis. BCC is a DEA model that implemented Variable Return to Scale (VRS) was known as model BCC, Banker, Charnes dan Cooper [6].

Maximation

H_0 = \sum_{r=1}^{s} Y_{rj_0} \quad (5)

Subject to:

\sum_{i=1}^{m} X_{i j} V_{ij} 0 = 1 \quad (6)
\sum_{r=1}^{s} Y_{rj} = \sum_{i=1}^{m} X_{i j} V_{ij} \leq 0 \quad j = 1, 2, ..., n \quad (7)
Y_{r} \geq 0; \ X_{i} \geq 0

j_0 : tested unit
j : another unit that comparable
n : a sum of the analyzer unit
m : sum of input
s : sum of output
V_i : a sum of input to-I analyzed
U_r : a sum of input to-r analyzed unit
Y_r : output value to-r analyzed unit
X_i : Important weighted value to-i analyzed unit.

3. Research Method

Primary data were collected by deep interview with an intermediary traders and direct observation of their business unit location. Data collection of broilers marketing distribution flows from live birds on the farm to the traditional market to identify product volume distributed and cost expense during the distribution process. Processing data steps are as follows:
a. Broiler marketing distribution lane mapping based on value-added calculation. This research focus to study broiler distribution line and supply chain map.

b. Measure relative effectiveness of the intermediary traders used a ready-to-use Excel Solver-based DEA software called DEA Frontier.

Sampling uses to choose the intermediary trader is a nonprobability sampling method with a purposive sampling technique, considering that the selected sample units meet certain criteria based on the research objectives. Total sampling object is 11 intermediary traders that called the Decision-Making Unit (DMU). The result of observations and interviews with related providers also considered in calculate the input and output variable which determine performance measurement. The input consist of product cost, distribution cost, equipment, and vehicle maintenance cost, direct labor cost, and overhead cost. The product cost is the price pay by an intermediary trader to the farmer, determine by the buying volume and price per kg of live birds. The distribution cost is the fuel cost, driver wage and cost to keep the chicken meat in certain temperature by add ice on the package. The output variable is the revenue gain by the trader from selling the product to a big seller.

4. Result and discussion

4.1. Added Value Calculation

Added value calculations use a cost analysis approach for intermediary traders and market traders. The data used for this calculation is based on the results of the interview. The added value occurs in chicken products along with the transfer of products from one chain to the last chain, become one of a factor in the formation of chickens selling price at the consumer level. The results are as shown in Table 1.

| Table 1. Added Value Calculation | intermediary trader | seller/retailer |
|-----------------------------------|---------------------|----------------|
|                                   | A                   | B              |
| Selling volume (kg)               | 1,205               | 153            |
| Product price                     | 16,800              | 30,000         |
| Revenue (Rp)                      | 23,495,909          | 3,604,809      |

| Expenditure                       | E                   | F               |
|-----------------------------------|---------------------|----------------|
| Investment cost (cost per day)    | 265,372             | 34,826         |
| Operational cost                  | 20,918,636          | 3,160,975      |
| Overhead cost                     | 48,355              | 2,000          |
| Equipment                         | 7,136               | 1,000          |
| Maintenance cost                  |                     |                |
| Distribution cost                 | 150,909             | 0              |

| Sum of E to I                     | Total Cost          |
|-----------------------------------|---------------------|
| Total production cost             | 18,879              | 30,255         |
| Selling price                     | 21,280              | 30,255         |
| Profit bruto                      | 2,203,185           | 406,007        |
| Tax (10%)                         | 220,318             | 40,601         |
| Net profit                        | 1,982,866           | 365,407        |

| Percentage of net profit          | 0.10                | 0.10           |

Value added is a value that occurs because of one commodity experience the process of processing, transporting and storing in one process production. Value added is influenced by technical factors and non-technical factors. Information or output obtained from results Value-added analysis is the amount of added value, a ratio of value-added, margin and remuneration received by the owner of the factor of production [6].

Table 1 is the basis for determining the value added at each chicken supply chain actors. The values in Table 1 are divided by the number of kilograms of input of the main raw material so that the value-
added chain of broiler products is given in Table 2. Based on the interview, the broker only takes profit of Rp 361 per kg for purchase the live birds from a farm and sell it to an intermediary trader. Then, the trader will transport the live birds to a location of a chicken slaughterhouse. The intermediary traders gain profit around IDR2,000,-/kg to IDR3,000,-/kg, then the selling price of chickens was formed at intermediary traders around IDR20,000,-/kg. After that, the chicken carcass will be distributed to market traders to be sold to end-level consumers. The weight losses from live birds to chicken carcass is about 30% or more. Also, some losses caused by certain live bird mortality rate.

| Table 2. Value Added Every Marketing Distribution Per Day |
|-----------------|-------------|-----------|-----------|
| Trader          | Broker      | Intermediary | Seller    |
| Purchase Price  | 19,875      | 20,236     | 3,111     |
| Selling price   | 20,236      | 25,051     | 3,660     |
| Added value     | 361         | 4,815      | 549       |
| Index of added value | 1.018    | 1.238      | 1.177     |
| Profit per kg   | 300         | 2,362      | 3,065     |

The selling price of chicken at the farmer is based on the average selling price of live bird in 2016 [7], and the selling price of carcass at the market seller based on the average selling of chicken meat in 2016, which is around IDR30,000/kg. Price disparity of chicken meat in intermediary traders and market traders is IDR10,000 / kg due to the losses of chickens weight. Weight losses approximately 70% of total body weight. For example, the weight of 1 lives bird from a farm is 1.8 kg, after being slaughtered and cleaned it will shrink to 25% so that the weight becomes 1.35 kg, and when cut carcasses (separated from the head, claw, gizzard, and intestines) the weight of chicken meat shrinks 5% more. In processing industries based on agriculture product, there is a change from the main raw material to the finished product which is expressed as a product conversion index [7].

Furthermore, in the market, a cleaned chicken will be cut into carcasses and sold to the end consumers based on actual weight. In addition, there are risk borne by a market seller if the product is not sold out on that day. Chicken meat is a perishable product that the quality will decrease physically according to the function of time, air temperature, transport distance, air humidity level and so on.

Based on the illustration above, it can be seen that the role of the intermediary trader is important in the formation price at the end customer. It is necessary to pay attention to the efficiency of the intermediary trader to reduce the selling price. Efficiency improvements are needed by considering input costs so that resources can be allocated properly.

4.2. Data Envelopment analysis

The input and output data used given on in Table 3. All value in rupiah. Processing data use Excel Solver-based DEA software called DEA Frontier. From the output of this software, the value of relative efficiency, weight for each input and output variable, peer group, and the determination of target inputs and outputs to achieve efficiency improvements from each DMU will be known. Table 6 describes the results of the DEA calculation of CRS (constant return to scale) input oriented with DEA Frontier. Based on Table 4, the calculation of proposed improvements for DMUs that inefficient to achieve the ratio of virtual output input is by changing the number of variables needed so that each input-output variable achieve the targeted value or achieve efficient criteria.

The result of DEA Frontier data processing shows that relatively inefficient DMUs are DMU 3, 5, and 6. Peer Group / Benchmark used to determine the reference DMU. Reference DMU became a reference for improvement of inefficient DMU to increase the efficiency value of the intermediary traders. The slack movement and the improvement target to increase the efficiency of the inefficient DMU is the results of the DEA Frontier given in Table 5.
### Table 3. Data Recapitulation Per Day (in IDR)

| DMU | Revenue  | Purchase     | Distribution cost | Overhead cost | Labor cost | Maintenance cost |
|-----|----------|--------------|-------------------|---------------|------------|------------------|
| 1   | 15,600,00 | 12,600,000   | 90,000           | 258,333       | 850,000    | 0                |
| 2   | 29,658,33 | 25,200,000   | 90,000           | 152,500       | 500,000    | 10,000           |
| 3   | 15,928,88 | 13,440,000   | 150,000          | 136,666       | 600,000    | 1,833            |
| 4   | 38,433,33 | 33,600,000   | 100,000          | 100,000       | 900,000    | 5,000            |
| 5   | 19,633,33 | 16,800,000   | 200,000          | 200,000       | 300,000    | 5,000            |
| 6   | 28,950,00 | 25,200,000   | 250,000          | 230,000       | 680,000    | 5,000            |
| 7   | 23,126,66 | 20,160,000   | 100,000          | 185,833       | 180,000    | 1,667            |
| 8   | 47,972,22 | 42,000,000   | 400,000          | 95,000        | 595,000    | 40,000           |
| 9   | 2,886,667 | 2,520,000    | 90,000           | 35,000        | 645,000    | 0                |
| 10  | 16,187,77 | 14,280,000   | 100,000          | 28,571        | 460,000    | 5,000            |
| 11  | 20,077,77 | 16,800,000   | 90,000           | 120,000       | 750,000    | 5,000            |

### Table 4. Recapitulation of TeCRS & Peer Group

| DMU | TeCRS | Peer Group/Benchmark |
|-----|-------|----------------------|
| 1   | 1     | -                    |
| 2   | 1     | -                    |
| 3   | 0.996574 | 1, 4, 7, 11         |
| 4   | 1     | -                    |
| 5   | 0.998957 | 1, 2, 7             |
| 6   | 0.977107 | 1, 2, 7, 11        |
| 7   | 1     | -                    |
| 8   | 1     | -                    |
| 9   | 1     | -                    |
| 10  | 1     | -                    |
| 11  | 1     | -                    |

### Table 5. Improvement Recapitulation/Slack

| DMU | Cost and Revenue | Actual | Slack | Target |
|-----|------------------|--------|-------|--------|
| 3   | Production       | 13,440,000 | 0     | 13,440,000 |
|     | Distribution    | 150,000    | 82,065| 67,935   |
|     | Overhead        | 136,666    | 0     | 136,666  |
|     | Labour          | 600,000    | 0     | 600,000  |
|     | Maintenance     | 1,833      | 0     | 1,833    |
|     | Revenue         | 15,688,888 | 0     | 15,928,889 |
|     | Production      | 16,800,000 | 0     | 16,800,000 |
|     | Distribution    | 200,000    | 131,975| 68,025   |
| 5   | Overhead        | 200,000    | 77,481| 122,519  |
|     | Labour          | 300,000    | 0     | 300,000  |
|     | Maintenance     | 5,000      | 0     | 5,000    |
|     | Revenue         | 19,333,333 | 0     | 19,333,333 |
|     | Production      | 25,200,000 | 0     | 25,200,000 |
|     | Distribution    | 250,000    | 126,728| 123,271  |
| 6   | Overhead        | 230,000    | 0     | 230,000  |
|     | Labour          | 680,000    | 0     | 680,000  |
|     | Maintenance     | 5,000      | 0     | 5,000    |
|     | Revenue         | 28,950,000 | 0     | 28,950,000 |
Government policies on import permits for chicken breeders should be reviewed to regulate the supply of domestic stock. The number of GGPS (Great Grand Parent Stock) imported determines the amount of DOC production and a live bird. The imbalance on supply and demand on broiler meat happens in Indonesia in 2014. Oversupply on live bird gives an impact on live bird selling price. A problem of falling selling price in 2014 occurs because the number of imports of the GGPS is more than it should be. Oversupply live chicken in 2010 is still 31.27% of national consumption, but in 2013 reached 55.08%, then in 2014 reached 65.75%. Government role is needed on the regulation of the supply and demand of live birds to avoid price fluctuation[9].

Further guidance, applying cold chains is needed from the intermediary stage to seller or retailer. The cold chain should be promoted to the wider community because chicken meat is a perishable product with high water and protein content that suitable for a microorganism to grow rapidly and caused physical changes due to unsuitable air temperature, time, and air humidity. A cold chain is an appropriate preventive action to maintain the quality of the chicken meat.

Monitoring is needed by various stakeholders in the agribusiness supply chain of traditional broiler industries so that consumers can get broiler products in good quality and inappropriate prices. Government effort to reduce the fluctuation on prices of chicken meat in the market is needed by regulating the balance of supply and demand, also facilitate the application of cold chain systems equipment in all marketing distribution stage. The market price is determined by the balance of supply and demand. Therefore, the accuracy of supply and demand data is required to maintain the balance of live bird selling price. The market price of a live bird from a farmer is determined from the amount of supply and the amount of market demand.

5. Conclusion
A poultry supply chain consists of farmers and intermediary traders such as brokers, collectors, and seller/retailer. Each actor has different added value in the supply chain. The difference in value added is influenced by the varying volume of chicken sold by each intermediary per day. The selling price of meat at consumers influenced by the purchase and selling price of the intermediary traders and shrinkage on body weight (30%), and the profit level define by the seller.

Based on the calculation of the relative efficiency of 11 DMUs, 3 DMUs were inefficient with $\text{TE}_{\text{CRS}}$ value less than 1 (one). DMU / Intermediary Parties (collectors) that are still inefficient must increase their efficiency by making improvements to the influential input variables. DMU 3, 5 and 6 need to reduce distribution cost. The average ratio of value added of intermediaries (traders) is around 1.24, categorize as efficient.

Acknowledgement
Researchers would like to thank to Industrial Engineering student and all the people involved for the cooperation for this study. This research was financially supported by the Faculty of Engineering, Diponegoro University in scheme of Hibah Strategis 2019.

References
[1] Director General of Livestock and Animal Health 2012 Strategic Plan
[2] Bowersox D. J., Closs D. J., and Cooper M. B 2012 Supply chain logistic management (New York: McGraw Hill)
[3] Purwaningsih, R., Arief, M., and Rahmawati, D 2016 Analisis Rantai Pasok dan Distribusi Ayam Pedaging. Proseding Seminar Nasional Teknik Industri Universitas Gadjah Mada (Indonesia: Departemen Teknik Mesin dan Industri Fakultas Teknik Universitas Gadjah Mada)
[4] Charnes A, Cooper WW, Rhodes E 1978 Eur.J. Oper. Res 2 429–44
[5] Wen, M 2015 Uncertain Data Envelopment Analysis, Uncertainty and Operations Research (Berlin: Springer)
[6] Hayami Y, Kawagoe T, Morooka Y, Siregar M 1987 Agriculture marketing and processing in upland Java, A Perspective from a Sunda village CGPRT No. 8 (Bogor: CGPRT Center)
[7] Majalah Pinsar Indonesia online edition 2017 available at http://pinsarindonesia.com
[8] Purwaningsih R 2018 Analisis Nilai Tambah Produk Perikanan Lemuru Pelabuhan Muncar Banyuwangi 14 13-23
[9] R Purwaningsih et al 2018 IOP Conf. Ser.: Mater. Sci. Eng. 403 012044