



The Price Dynamics of Hand Sanitizers for COVID-19 in Indonesia: Exponential and Cobweb Forms

Amir Machmud^{1*} Asnul Dahar Bin Minghat²

¹Faculty of Economics and Business Education, Universitas Pendidikan Indonesia, 40154 Bandung, Indonesia

²Faculty of Technology and Informatics, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

*Correspondence E-Mail: amir@upi.edu

ABSTRACTS

This study aims to analyze the impact of the COVID-19 pandemic on changes in handsanitizer prices in Indonesia. This study is motivated by the increasing demand for handsanitizers which has had an impact on price ratings. The method used is an explanatory survey with an exponential form approach for the demand function and Linear Cobweb Form for the supply function. The structure of the hand sanitizer market is assumed to be a perfectly competitive market. The results of the study indicate that despite changes in prices, the numerical analysis shows that prices are stable. The entry and exit of companies in the market does not affect price stability. This finding implies that after the pandemic the prices of handsanitizers will return to normal, so producers and consumers must remain rational.

© 2020 Tim Pengembang Jurnal UPI

ARTICLE INFO

Article History:

Received 06 Mar 2020

Revised 01 May 2020

Accepted 03 May 2020

Available online 04 May 2020

Keywords:

Covid19,

The price dynamic,

handsanitizer,

Exponential Form,

Linier Cobweb Form

Indonesia.

1. INTRODUCTION

Since the World Health Organization (WHO) announced on March 11, 2020 related to changing PHEIC status to a pandemic, after a significant increase in the number of case reports and the number of deaths due to Novel Coronavirus virus (COVID19) in various parts of the world (World Health Organization, 2020) has had a great impact on all life activities including the economy. This virus has flu-like symptoms and respiratory infections (De Groot-Mijnes *et al.*, 2004). Before becoming a pandemic, this virus ini-

tially occurred in Wuhan City of Hubei Province, China in December 2019.. There is a report stating that an outbreak of pneumonia is related to a virus called Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) (Huang *et al.*, 2019; Zhu *et al.*, 2020; Li *et al.*, 2020). The number of confirmed Covid-19 cases from 22 January 2020 to 31 March 2020 experienced a very significant jump. The number of case reports worldwide was 802,639 with a total of 39,014 deaths and a total of 172,319 patients recovered (www.worldometers.info/coronavirus/).

One of the impacts of the COVID-19 Pandemic on the economy is shown by the potential for shocks in the demand and supply of goods and services. The impact of this outbreak prompted people to buy hand sanitizers to prevent corona virus transmission. The prices of hand sanitizers increased significantly from the normal prices. A number of well-known brands of hand sanitizers have increased by 81.12 percent on several e-commerce platforms, such as Shoppe, Bukalapak and Tokopedia. This condition has encouraged producers to increase the volume of hand sanitizer production, which in turn has an impact on increasing demands for chemicals such as ethanol by hand sanitizer manufacturers, disinfectants and antiseptics. Based on the records of the Indonesian Chemical Industry Federation (FIKI), the increase in chemicals was recorded around 10% -15% compared to normal conditions.

Price dynamics is a strategy, in which prices vary over time, consumers, and/or circumstances (Elmaghraby & Keskinocak, 2003; Gönsch *et al.*, 2013; Faith & Agwu, 2018; Elmaghraby & Keskinocak, 2003) and it distinguishes between two dynamic pricing models, namely the pricing mechanism and the price discovery mechanism. With price-posted mechanisms, price changes are often offered as "take-it-or-leave-it" price, i.e., the company is still in charge of setting prices. With price discovery mechanisms, such as eBay, Priceline, or similar negotiation approaches, consumers get input to set the final price. The study of price dynamics in general is inseparable from the concepts of demand and supply and price theory. Price theories have been widely advanced by experts (Mills, 1959; Muth, 1961; Petruzzi & Dada, 1999; Bi & Liu, 2014). Meanwhile, Collery (1955) examined the price expectations associated with the Cobweb theorem. Cobweb's theorem has to do with the form of the supply function, where the supply de-

cision considers the conditions of the past (Vaugh, 1964; Morgenstern, 1948; Collery, 1955) They use the linear form request function. The cobweb model describes a dynamic price process in a market by adjusting goods that cannot be stored and supplies that are owned by producers. The cobweb framework can consider interactions between two interconnected markets. Interaction can occur when producers enter different markets. This process is carried out every specific time period depending on the profit generated by the producer. The decision of producers is influenced by the state of prices in different markets each period, so most producers choose markets that have greater profits. Cobweb model is one that is not linear. In principle, the cobweb model can be useful to investigate the elasticity of supply and demand elasticity due to price fluctuations and the amount of production. There are six assumptions of the cobweb model that must be fulfilled: 1) the price is determined by the competitive structure that occurs in the marketing process, 2) the price is determined in the short-term production process, 3) the production plan is based on new prices, 4) there is a grace period to provide production responses, 5) the price cycle that occurs depends on the actual production equation, and 6) demand and supply are static (Machmud, A 2016). The Cobweb model is one of the forecasting strategies that can be studied in detail (Vaugh, 1964; Day & Tinney, 1969). Parameters used in this analysis illustrate the evolution of forecasting strategies. The Cobweb model also illustrates the transition between rational estimates and not, there is a wrong behavior when discovering the value of supply of goods and elasticity demand is large enough (Dawid & Kopel, 1998; Franke, 1998). Producers have assumptions about future price estimates heterogeneously (Hommes, 2011). Before determining price estimates, producers must describe produc-

tion decisions and market needs. The results show that the cobweb theory is appropriate for discussing price fluctuations, supply quantities, demand for variable variables affect the demand and supply of agricultural products (Waugh, 1964; Day & Tinney, 1969; Pashigian, 1970).

Exponential function is one of the important functions and is often used in mathematics (Clenshaw & Olver, 1980; Confrey & Smith, 1995; Rovira & Rovira, 2010). Exponential functions have been extensively studied by mathematicians (Bartlett, 1976; Lam & Goodman, 2000; Tegmark, 2008; Debnath, 2015; Salas *et al.*, 2010). From the studies that have been conducted, several definitions have been produced in different forms of exponential functions, logarithms and limits.

This study aims to analyze the impact of COVID-19 on the balance of the hand sanitizer market in Indonesia with the approach of the exponential demand function and the linear cobweb supply function. The study method used was exploratory survey with data analysis techniques sourced from articles that have been published in the mass media and national and international journals. The assumption used in the handsanitizer market structure is perfect competition with the characteristics of (i) Many buyers and sellers in the market, (ii) Goods offered by many companies are uniform, and each company follows the market price, and (iii) companies are free in and out. The results of the study are expected to be used as input for policy makers in dealing with covid-19.

2. MATERIALS AND METHODS

2.1. Demand and Supply Function

Demand is the desire of consumers to buy an item at various price levels over a certain period of time. The amount of goods demanded by consumers in addition to depending on price is also determined by factors: (i). Prices of other related goods; (ii).

Per capita opinion level; (ii). Taste or habit; (iv). Total population; (v). Estimated item in the future; (vi). Distribution of community income; and (vii). Producer's efforts to increase sales (Machmud *et al.*, 2016; Machmud *et al.*, 2018). Changes in these factors will determine the quantity demanded by consumers for the goods they want (Mojaveri & Moghimi, 2017). We assume that there are consumers and producers. and each producer produces and goods that consumers want to consume. We also assume that the number of consumers does not change over time. In general, the request function can be declared with the equation:

$$Y_i = f_i(x_1, x_2, \dots, x_n), i = 1, 2, \dots, m \quad (1)$$

which is assumed to be a continuous function. If x_1 is the price, then according to the law of demand, *ceteris paribus*

$$\frac{df_i(x_1)}{dx_1} < 0 \quad (2)$$

Inequality (2) does not apply to goods that have elements of speculation, prestige, and gifen. The equation function (1) which fulfills (2) is called the individual demand function for an item, and is called the consumer behavior equation [7]. Furthermore, the market demand function is as follows:

$$Y^D = \sum_{i=1}^m f_i(x_1, x_2, \dots, x_n) \quad (3)$$

Furthermore, supply is the price of goods that producers want to offer (sell) at various price levels during a certain period. Factors affecting supply are: (i) the price of the goods themselves, (ii) the prices of other related goods, (iii) factor prices, (iv) production costs, (v) production technology, (vi) number of traders or sellers, (vii) corporate objectives, and (viii) government policies (Machmud *et al.*, 2018).

Changes in these factors will cause changes in the quantity of bids by the company. Furthermore, in general the bid function is stated as

$$y_j = g_j(x_1, x_2, \dots, x_n), j = 1, 2, \dots, k. \quad (4)$$

If X_1 is the price, then according to the law of supply, *ceteris paribus*, then (4) complies Inequality

$$\frac{df_i(X_1)}{dx_1} > 0 \quad (5)$$

The function of equation (4) that satisfies (5) is called the function of the supply of goods by a company, and is called the equation of company behavior (Machmud *et al.*, 2018). The market supply function is

$$y^S = \sum_{j=1}^k g_j(x_1, x_2, \dots, x_n) \quad (6)$$

Changes in the variables y of equations (1) and (4) due to changes in x_1, x_2, \dots, x_n , graphically, cause the demand curve and supply curve to shift to the right or left; x_1, x_2, \dots, x_n is called a movement factor [9].

2.2 Market Price Dynamics

We will use the exponential demand function as the consumer demand function of (1), which is:

$$y_i(t) = \alpha_i e^{-\delta_i p(t)}, \alpha_i > 0, \delta > 0; i = 1, 2, \dots, m \quad (7)$$

Deman Function from (7) we can state with

$$y^D = \alpha e^{-\delta p}, \alpha > 0, \delta > 0 \quad (8)$$

where $\alpha = \sum_{i=1}^m \ln(\alpha_i)$ dan $\delta = \sum_{i=1}^m \delta_i$

Supply Function is linear :

$$y_j = \alpha_j + b_j p(t - 1), b_j > 0, j = 1, 2, \dots, k \quad (9)$$

The Market Supply Function from (9) can be expressed as follows:

$$y^S = \alpha + bp(t - 1), \alpha > 0, b > 0 \quad (10)$$

where $\alpha = \sum_{j=1}^k \alpha_j$ dan $b = \sum_{j=1}^k b_j$. Value is the quantity of stock sold, while b is the tendency to sell by the company. From (8) and (10) a market price is obtained that meets the balance nature of $y^D = y^S$

$$p(t) = \frac{1}{\delta} \ln \frac{e^{\alpha}}{\alpha + bp(t-1)} \quad (11)$$

where $p(t - 1) > 0$. If another company produces similar goods, and competes in the market, the company initially follows the price of $p(0)$ to sell its production goods. However, after the company operates all the time t , assuming demand does not change, the price of $p(t)$ will go down. This is due to the increase in the value of the coefficient b from equation (10), as a result of the entry of a new company into the market, where the quantity of goods sold in the market rises. If the driving factors x_1, x_2, \dots, x_n are also considered in model (11), then the price of $p(x_1, x_2, \dots, x_n)$ will fluctuate over time.

3. RESULTS AND DISCUSSION

3.1. The Development of Handsanitizer Prices in Indonesia at Covid19

Based on a report on the price comparison, the prices of hand sanitizers have increased many times. A number of well-known brands of hand sanitizer soared high in several e-commerce platforms, such as Shoppe, Bukalapak and Tokopedia around 81.12 percent. The sample data were taken in the span of time from February 26, to March 4, 2020. The highest sales figures occurred on March 2, 2020 with a total value of Rp159,560,430 from 1,613 transactions. The average product purchased was in the form of a 50 to 500 ml hand sanitizer, with a price range of Rp. 25,000 to 155,000 per bottle. Seeing the surge in transactions, not

a few there were some sellers who set prices above normal. More clearly can be seen in **Figure 1**.

The high demand for these products, making Tokopedia provide a special page so that users can buy and search for health goods more easily. Not to forget Tokopedia provides cashback promos for every product purchase through its platform. A number of preventive measures have also been taken by e-commerce platforms such as Amazon and eBay. Both companies imposed a ban on not selling health products with frills that can prevent or cure the coronavirus. Amazon even will explicitly delete every ad sold by its users if it is known to set an unreasonable price, for health products such as masks, hand sanitizers and medicines. While eBay has reportedly removed 20,000 lists of items that have been verified as selling coronavirus-related items.

3.2. Hand Sanitizer Market Equilibrium :

Research Results Dynamic market models, both Qd (demand) and Qs (supply) are taken as the current price function P only. Information about price trends is mainly obtained in two derivatives $dv dt$ and $d^2p dt^2$. To consider price trends. now enter

these derivatives as additional arguments in the supply and demand functions:

$$Qd = [(t), P'(t), P''(t)] \quad (12)$$

$$Qs = [(t), P'(t), P''(t)] \quad (13)$$

If it limits the linearity of the function and simplifies the notation for the independent variables P, P' and P'' , it can be written:

$$Qq = \alpha - \beta P + mP' + nP'' \quad \alpha, \beta > 0 \quad (14)$$

$$Qs = -y + \delta P + uP' + wP'' \quad y, \delta > 0 \quad (15)$$

It has been explained that the market balance is achieved if the quantity demanded is equal to the quantity supplied. Thus mathematically the equilibrium requirements are

$$\alpha - \beta P + mP' + nP'' = -y + \delta P$$

$$nP'' + mP' - \beta P + \alpha = \delta P - y$$

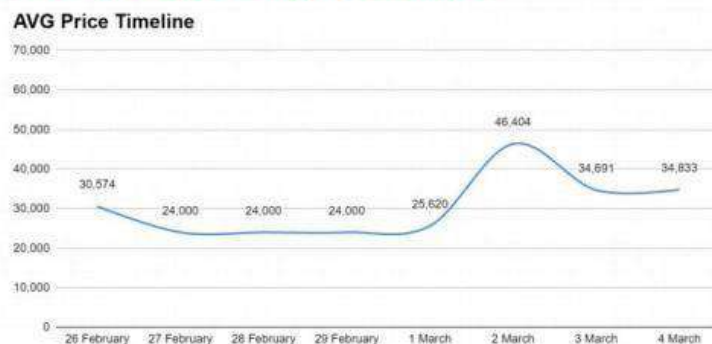
$$nP'' + mP' - \beta P - \delta P = -\alpha - y$$

$$nP'' + mP' - (\beta + \delta)P = -(\alpha + y)$$

Equation simulation (11) will be performed for various values a and b , by choosing $\delta = 1, = 100, a = 50, b = 1$, and $a = 70, b = 2$, then illustrated by changes in price dynamics $p(t)$ through chart. Using the Excel program, the $p(t)$ graph is shown in **Figure 2**.

The momentary change of the price of $p(t)$ is $P'(t) = -()$ (17) If selected $p'(0) = 0.07, \delta = b, a = 50$, then the behavior of price changes is shown in **Figure 3**.

Volume
 During Corona Issues, AVG price of Hand Sanitizer increasing to **81.12% in Tokopedia, Bukalapak & Shopee**



Source: Kompas Market Insights Dashboard - Data period : Feb 26th - Mar 4th 2020 - based on Sales & transactions data from All Category in Shopee, Bukalapak, and Tokopedia

Figure 1. The development of hand sanitizer prices at covid 19 in Indonesia

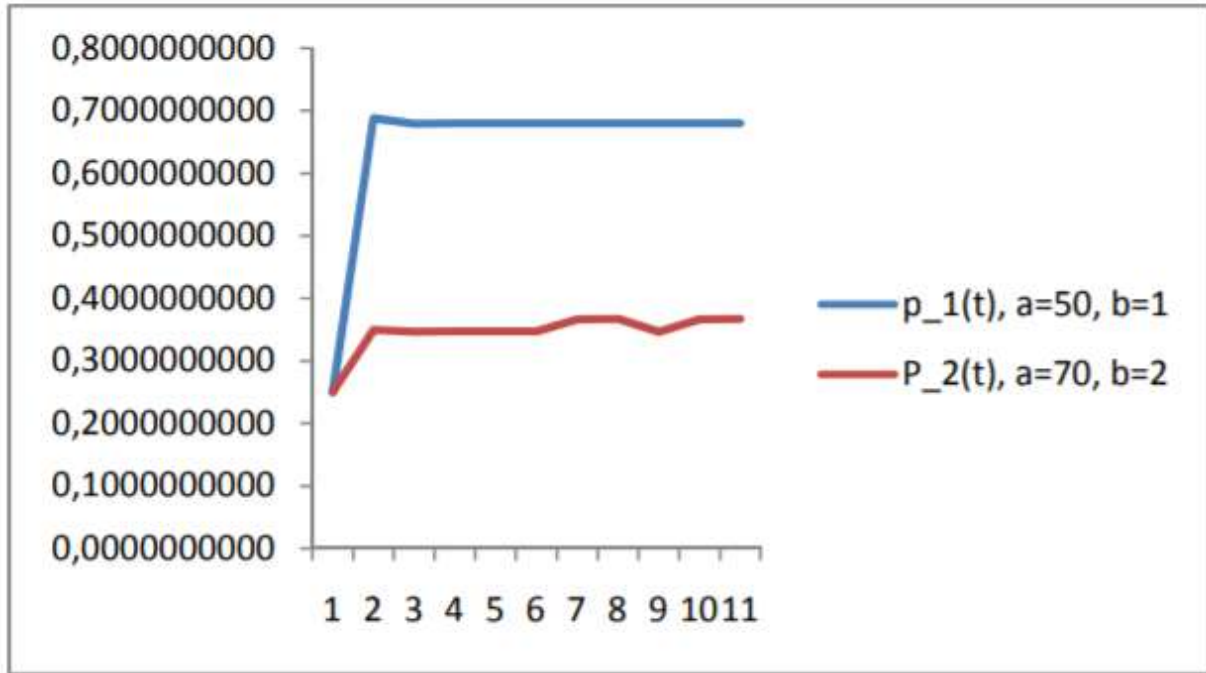


Figure 2. Price dynamics $p(t)$ due to the entry of new companies

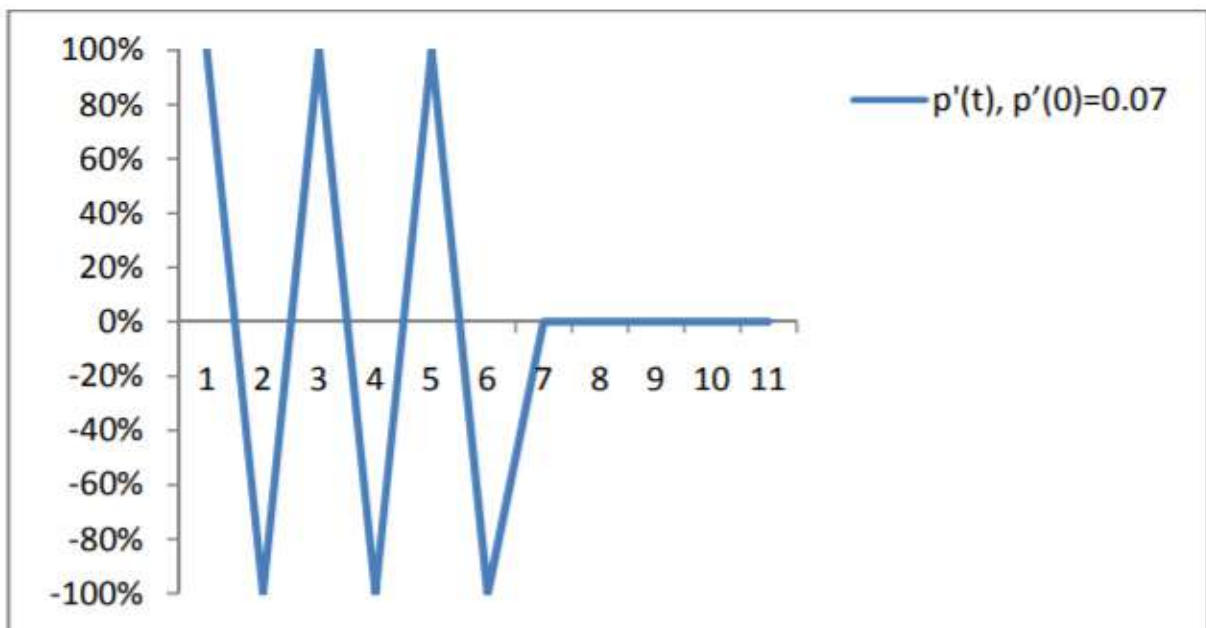


Figure 3. The Price Change Behavior $p'(t)$

In addition, **Figure 2** also shows that the change in price of $p'(t)$ converges to 0. The entry of a new company will cause the value of $p'(t)$ in equation (12) to decrease, because the value of $p(t)$ in equation (11) goes up. However, $p'(t)$ remains convergent to 0.

And vice versa, the exit of the company from the market, causing $p'(t)$ to fall, but still convergent to 0. In other words, the entry and exit of the company, will not cause market price instability.

4. CONCLUSION

This study has provided an explanation of price dynamics in perfectly competitive markets, where the demand function is exponential, and the Cobweb form is linear. In this explanation, it is assumed that the demand is fixed for prices, *ceteris paribus*. The results of numerical analysis show that the dynamics of market prices are stable.

The entry and exit of companies in the market shows that market prices have remained stable.

5. AUTHORS' NOTE

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article. Authors confirmed that the data and the paper are free of plagiarism.

6. REFERENCES

- Bartlett, A. A. (1976). The exponential function—Part 1. *The Physics Teacher*, 14(7), 393-401.
- Bi, W., & Liu, M. (2014). Product demand forecasting and dynamic pricing considering consumers' mental accounting and peak-end reference effects. *Journal of Applied Mathematics*, 2014, 1-10.
- Collery, A. P. (1955). Expected price and the cobweb theorem. *The Quarterly Journal of Economics*, 69(2), 315-317.
- Confrey, J., & Smith, E. (1995). Splitting, covariation, and their role in the development of exponential functions. *Journal for Research in Mathematics Education*, 26(1), 66-86.
- Clenshaw, C. W., & Olver, F. W. (1980). An unrestricted algorithm for the exponential function. *SIAM Journal on Numerical Analysis*, 17(2), 310-331.
- Dawid, H., & Kopel, M. (1998). On economic applications of the genetic algorithm: a model of the cobweb type. *Journal of Evolutionary Economics*, 8(3), 297-315.
- Day, R. H., & Tinney, E. H. (1969). Cycles, phases and growth in a generalised cobweb theory. *The Economic Journal*, 79(313), 90-108.
- De Groot-Mijnes, J. D. F., van Dun, J. M., van der Most, R. G., & de Groot, R. J. (2004). Natural History of a Recurrent Feline Coronavirus Infection and the Role of Cellular Immunity in Survival and Disease. *Journal of Virology*, 79(2).
- Debnath, L. (2015). A brief history of the most remarkable numbers e , i and γ in mathematical sciences with applications. *International Journal of Mathematical Education in Science and Technology*, 46(6), 853-878.
- Elmaghraby, W., & Keskinocak, P. (2003). Dynamic pricing in the presence of inventory considerations: Research overview, current practices, and future directions. *Management Science*, 49(10), 1287-1309.
- Faith, D. O., & Agwu, E. (2018). A review of the effect of pricing strategies on the purchase of consumer goods. *International Journal of Research in Management, Science and Technology*, 2(2), 88-102.
- Franke, R. (1998). Coevolution and stable adjustments in the cobweb model. *Journal of Evolutionary Economics*, 8(4), 383-406.

- Gönsch, J., Klein, R., Neugebauer, M., & Steinhardt, C. (2013). Dynamic pricing with strategic customers. *Journal of Business Economics*, 83(5), 505-549.
- Hommes, C. (2011). The heterogeneous expectations hypothesis: Some evidence from the lab. *Journal of Economic Dynamics and Control*, 35(1), 1-24.
- <https://www.worldometers.info/coronavirus/>, retrieved on March 31, 2020
- Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., & Cheng, Z. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet*, 395(10223), 497-506.
- Lam, E. Y., & Goodman, J. W. (2000). A mathematical analysis of the DCT coefficient distributions for images. *IEEE Transactions on Image Processing*, 9(10), 1661-1666.
- Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., & Xing, X. (2020). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *New England Journal of Medicine*, 382(13), 1199-1207.
- Machmud, A. (2016). Analysis of structure, conduct and performance of sharia insurance industry in Indonesia. *International Business Management*, 10(23), 5517-5522.
- Machmud, A., Nandiyanto, A. B. D., & Dirgantari, P. D. (2018). Technical efficiency chemical industry in Indonesia: Stochastic frontier analysis (SFA) approach. *Pertanika Journal of Science and Technology*, 26(3), 1453 - 1464.
- Mills, E. S. (1959). Uncertainty and price theory. *The Quarterly Journal of Economics*, 73(1), 116-130.
- Mojaveri, H. S., & Moghimi, V. (2017). Determination of economic order quantity in a fuzzy EOQ model using of GMIR defuzzification. *Indonesian Journal of Science and Technology*, 2(1), 76-80.
- Morgenstern, O. (1948). Demand theory reconsidered. *The Quarterly Journal of Economics*, 62(2), 165-201.
- Muth, J. F. (1961). Rational expectations and the theory of price movements. *Econometrica: Journal of the Econometric Society*, 29(3), 315-335.
- Pashigian, B. P. (1970). Rational expectations and the cobweb theory. *Journal of Political Economy*, 78(2), 338-352.
- Petruzzi, N. C., & Dada, M. (1999). Pricing and the newsvendor problem: A review with extensions. *Operations Research*, 47(2), 183-194.
- Rovira, P., & Rovira, R. (2010). Fitting litter decomposition datasets to mathematical curves: towards a generalised exponential approach. *Geoderma*, 155(3-4), 329-343.
- Salas, A. H., Gómez, S., & Cesar, A. (2010). Application of the Cole-Hopf transformation for finding exact solutions to several forms of the seventh-order KdV equation. *Mathematical Problems in Engineering*, 2010, 1-14
- Tegmark, M. (2008). The mathematical universe. *Foundations of Physics*, 38(2), 101-150.

Waugh, F. V. (1964). Cobweb models. *American Journal of Agricultural Economics*, 46(4), 732-750.

World Health Organization (WHO). (2020). WHO Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. <https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020>. Retrieved on January 11, 2020.

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., & Niu, P. (2020). A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*, 382(8), 727-733.