Analysis of Rice Price Transmission along the Supply Chain in Indonesia

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Abstract

The incomplete explanation on price transmission means that the problem of high differences in prices at the farmer level and prices at the end consumer level is not much resolved. This study aims to investigate the existence of *asymmetric price transmission* (APT) in the Indonesian rice market and then analyze indications of *welfare transfer* from the APT information. Using NARDL, this study shows that there is a positive APT along the supply chain, meaning that the response to price increases is greater compared to price decreases. The existence of this APT shows *market power,* where wholesalers have the greatest dominance, especially from their ability to create additional profits from price changes at the producer level.

Keywords: *asymmetric price transmission*; NARDL; *welfare transfers*

JEL classification: E31, Q11

Background

Understanding price transmission is important but there has not been much serious attention to this, especially for strategic commodities in Indonesia, one of which is rice. Although various studies have been conducted regarding rice price transmission in Indonesia (Hutami, 2018; Laili et al., 2019; Mashitoh, 2019; Novianti et al., 2020; Yustiningsih, 2012) these studies only show high differences between paddy rice price at the farmer level with the price of rice at the consumer level or the high difference between the price of rice at the producer level and the price of rice at the consumer level and the response between these prices when there is a change in one of the prices. However, there is not much explanation as to why the price of rice at the producer level and the price of rice at the final consumer level has such a high price difference. In fact, from the perspective of policy makers, more knowledge on price transmission is mandatory and must not be ignored if price stability is to be achieved, especially for developing countries (Rashid, 2011) .

This incomplete explanation on price transmission means that the problem of high differences in prices at the farmer level and prices at the final consumer level is not much resolved. Looking at the price development from the producer level to the final consumer level over the last eight years in Figure 1.1, the difference in the price of rice per kilogram for medium quality[1] between producers and final retailers was initially around IDR 700 per kilogram (kg) in 2013 and then the gap tends to widen from year to year until it reaches around IDR 1,960 per kg in 2020. Then, looking at price developments from upstream to downstream over the last eight years, the price of paddy rice[2] is still too low compared to the price of rice on the market. The price of grain ranges from IDR 3,600 per kg to IDR 5,400 per kg, while the price of rice for consumers is around IDR 8,400 per kg to IDR 11,300 per kg. Prices at the farmer level remain low while prices at the consumer level have increased at a higher rate than the price of grain at the farmer level even though the

[1] The classification of rice quality classes based on Minister of Agriculture Regulation No. 31 of 2017 is (1) Medium Rice is rice with a minimum of 95% steam, a maximum water content of 14%, a minimum of 75% head of rice and a maximum of 25% broken grains; and (2) Premium Rice is rice with a minimum grain degree of 95%, a maximum water content of 14%, a minimum of 85% head rice and a maximum of 15% broken grains.

[2] Dried Unhusked Grain (GKP). based on Presidential Instruction No. 5 of 2015, grain quality is divided into: (1) Dried Unhusked Grain-GKP is paddy rice with a maximum moisture content of 25% and a maximum void/impurity content of 10%; (2) Dried Harvested Grain-GKG is grain with a maximum water content of 14% and a maximum void/impurity content of 3%

government has maintained and monitored price stability both at the farmer level and at the consumer level through HPP[3], HET[4] and market operations policies [5].

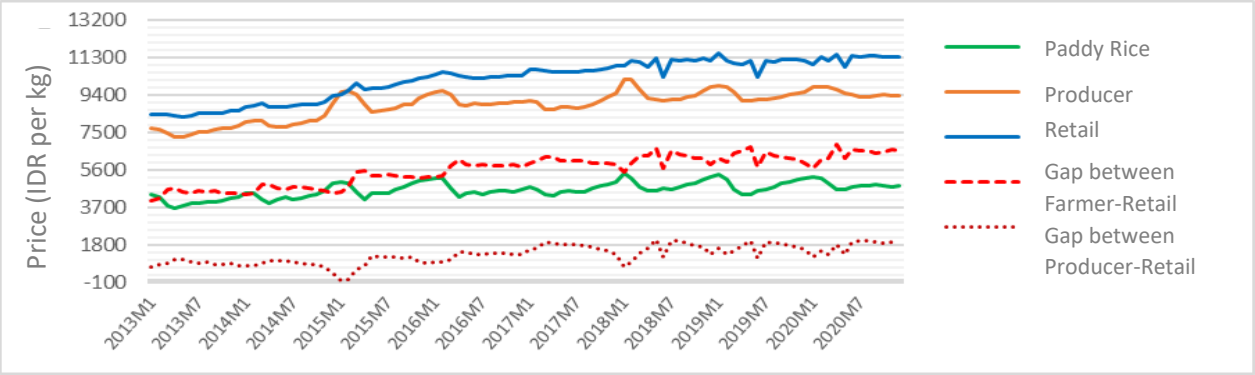


Figure 1.1 Paddy Price at Farmer Level, Rice Price at Producer and Retail Level
Source: BPS Statistics Indonesia and Ministry of Agriculture Indonesia (*processed*)

The high disparity in rice prices along the supply chain makes studies to understand price transmission along the rice supply chain interesting. Price transmission is a process where price movements in one market are influenced by price movements in other markets (Ghoshray, 2011) . There can be various forms of price transmission as long as it involves two markets, one of which is vertical price transmission where *upstream price movements* (*input prices* , for example prices at the grain farmer level) can affect *downstream prices* (*output prices,* for example prices at the rice producer level)[6] (Meyer & Cramon-Taubadel, 2004) . By studying price transmission, it can be shown to what extent the dynamics of price adjustments can provide information on the behavior of economic actors in each market as well as how the market mechanism works (Lloyd, 2017) . Therefore, the information from price transmission can be a basis to estimate whether a particular commodity supply chain is efficient or not (Meyer & Cramon-Taubadel, 2004) . A market is said to be inefficient when the prices spread along the supply chain exceed the transaction costs (Santeramo & Gioia, 2018) .

Regarding the analysis of price transmission itself, most studies find the existence of *Asymmetric Price Transmission* (APT) (Cao & Cheng, 2021; Deb et al., 2020; Hutami, 2018; Rahman, 2020; Yustiningsih, 2012) . APT is price transmission where increases and decreases in prices in one market will be responded differently in other markets (Goodwin & Holt, 1999) . When it comes to market efficiency, to analyze possible inefficiencies in the market, economists use the APT approach (Griffith & Piggott, 1994) .

The existence of APT is important according to economic literature (Meyer & Cramon-Taubadel, 2004) . First, the existence of APT shows that the economic model linking two markets assuming price movements in one market will be responded completely/fully in another market is no longer representative (Peltzman, 2000) . In example, the theoretical model developed by Gardner (1975) to see price elasticity between three markets based on Neoclassical General Equilibrium Theory. According to Cramon-Taubadel (1998) Gardner's (1975) model is actually able to predict the existence of asymmetric price transmission. Assuming a perfectly

[3]The Government Purchase Price (HPP) is a floor price mechanism - the minimum price that grain/rice may be sold at, with a mechanism for the government to purchase grain/rice at a price above the market price which started in 1967 in the form of a floor price (HD) becoming the government's basic purchase price (HDPP) in 2001 and subsequently became the government purchasing price (HPP) in 2003 (Suryana et al., 2014) . Currently, HPP based on Presidential Instruction No. 5 of 2005 is (i) GKP HPP is IDR 3,700/kg for farmers or IDR 3,750/kg for millers; (ii) HPP GKG is IDR 4,600/kg at the mill or IDR 4,650/kg at the BULOG Perum Warehouse; and (iii) Rice HPP (maximum water content quality 14%, maximum broken grains 20%, groats content 2% and minimum 95% brownness) is IDR 7,300/kg at the BULOG Perum Warehouse.

[4]Highest Retail Price (HET) is the highest selling price for packaged and/or bulk rice in people's markets, modern shops and other retail sales places which came into effect on 1 September 2017 (Minister of Trade Regulation No. 57 of 2017). For the regions of Java, Lampung, South Sumatera, Bali & West Southeast Sulawesi, and Sulawesi, the HET for medium rice is IDR 9,450/kg and premium rice IDR 12,800/kg. For the Sumatra region (except Lampung and South Sumatera) and Kalimantan, the HET for medium rice is IDR 9,950/kg and premium rice IDR 13,300/kg. For the Maluku and Papua regions, the HET for medium rice is IDR 10,250/kg and premium rice IDR 13,600/kg.

[5]Market operations are government actions in order to handle spikes in rice prices (prices at the consumer level increase by 10% compared to normal prices for at least 1 week or when it is disturbing the community based on local regional reports) that occur in certain areas during a certain period of time by using rice from reserves. Government Rice (Permendag No. 4 of 2012). There are two types of market operations, namely general and special market operations (Presidential Decree No. 46 of 2018). In General Market Operations, Bulog sells rice reserves when there is a spike in rice prices in the market with a price cut of around 10-15% below the market price, while special market operations or what is now called Rice for Poor Families (raskin) are aimed at the poor.

[6]It is possible that the direction of price transmission is that downstream prices *influence upstream prices*, *which could occur due to demand shocks downstream (* Meyer & Cramon - Taubadel , 2004) .

competitive market (where price responses between markets are symmetrical) and constant returns to scale, Gardner (1975) shows that price elasticity at the retail (consumer) level towards prices at the farmer level will be greater when triggered by shifts in consumer demand compared to shift in supply in farmers (Cramon-Taubadel, 1998) . This shows that if the shift in supply or demand is predominantly positive or negative, then the observed price transmission becomes asymmetrical/skewed, *indicating* the existence of an asymmetrical condition. However, by using *comparative statics analysis* of Gardner (1975) , the existence of asymmetry cannot be seen or even taken into account (Cramon-Taubadel, 1998) .

The existence of asymmetric price transmission is also found in the empirical model. Existing studies on agricultural commodities prices, i.e Cramon-Taubadel & Loy (1996); Deb et al. (2020); Kinnucan & Forker (1987); McCorriston et al. (2001); Rapsomanikis et al. (2004) and Peltzman (2000) showed that prices paid by consumers respond to increases in input prices for farmers more quickly than price decreases. Therefore, the perspective of the response of the price movements in one market to another market needs to be reconsidered because the existence of this APT indicates a transmission distribution that is different from the context of symmetric price transmission (Peltzman, 2000) .

Second, studying APT can provide information about welfare distribution among actors involved in the markets. For example, a decrease in prices at the farmer level which is responded more slowly by prices at the consumer level indicates a transfer of welfare from farmers to consumers (Meyer & Cramon-Taubadel, 2004). Another example, when price increases at the farmer level are responded more quickly/higher by prices at the consumer level indicates the possibility of welfare transfers that are not entirely received by farmers but more to middlemen (Meyer & Cramon-Taubadel, 2004 *)* . Therefore, having another point of view from APT is essential because by looking at the welfare distribution among market players, there will be policy and social consequences from the analysis of asymmetric price transmission (Meyer & Cramon-Taubadel, 2004) .

Discussions on welfare distribution of APT have not been widely discussed in APT research, especially for the rice market in Indonesia (Hutami, 2018; Laili et al., 2019; Mashitoh, 2019; Novianti et al., 2020; Yustiningsih, 2012) . The existing studies so far use the method developed by Cramon-Taubadel & Loy (1996) , where this method is only able to measure APT in terms of speed or transmission speed (Meyer & Cramon-Taubadel, 2004) . APT in terms of speed is included in Type I APT according to Meyer & Cramon-Taubadel (2004) . Measuring speed alone to see the existence of APT is not complete because Type I APT also provides APT information in terms of magnitude or amount of price transmission (Meyer & Cramon-Taubadel, 2004) which is not yet covered in existing studies .

Information on the existence of APT measured by its speed and magnitude is very necessary if you want to see the welfare distribution consequences of the existence of APT between markets. Meyer & Cramon-Taubadel, (2004) also introduced positive and negative APT developed by Peltzman (2000) to indicate the direction of welfare transfer between market players (Meyer & Cramon-Taubadel, 2004) . An APT is said to be positive when an increase in input prices is responded to more quickly by output prices than when a decrease in input prices, while a negative APR is a condition when a decrease in input prices is responded to more quickly than an increase in input prices (Meyer & Cramon-Taubadel, 2004) .

This study will look at the existence of APT starting from the market at the farmer, producer, wholesaler, to retailer level. The studies conducted in Indonesia so far has looked at price transmission from farmers directly to consumers (Laili et al., 2019; Yustiningsih, 2012) , from producers to consumers (Mashitoh, 2019; Novianti et al., 2020) , as well as from producers to wholesalers then to consumers (Hutami, 2018) . By looking at the APT along the supply chain, the welfare consequences among farmers, producers, wholesalers and retailers (who represent the final consumer) could be identified. Analysis of asymmetric price transmission along the supply chain, according to Meyer & Cramon-Taubadel (2004), is included as vertical APT [7]. The spatial APT, which is the transmission of prices at the same level in different markets (Meyer & Cramon-Taubadel, 2004), for example is a condition where an increase in the export price of Thai rice is responded more quickly than a decrease in the export price of Thai exports by the export price of Indonesian rice. However, this spatial APT was not included in this study.

Therefore, this research aims to see the existence of APT in the transmission of rice prices along the vertical supply chain, namely farmers, producers, wholesalers and retailers. Specifically, this research will estimate differences in speed and magnitude of rice price transmission that are triggered from price changes

[7]Vertical APT is a condition when prices increase/decrease in the input market is responded differently by the output market (Meyer & Cramon-Taubadel, 2004). The term of spatial APT, the transmission of prices at the same level in different markets, for example, an increase in the export price of Thai rice is responded more quickly, causing an increase in the price of Indonesian exports compared to a decrease in prices. However, it is not covered in this study.

at the farmer level to price changes at the retailer level (which reflects the final consumer) [8]. Based on this information, this research will explain the possibility of welfare distribution starting from price changes at the farmer level [9]. This study will analyze rice prices in 2014-2021 because during those period, there were several sudden increases in the price of grain at the farmer level, especially in 2015 and 2018. At the farmer level, the analysis of price changes will focus on Dried Unhusked Grain (GKP) considering that GKP is the largest type of grain produced by farmers, on average around 60% of grain production in a year (BPS, *data processed)*. Meanwhile, at the producer and wholesaler level, the price movements analyzed are the price of medium quality rice because this rice is the dominant rice consumed by the Indonesian people (Ministry of Trade, 2004) . Furthermore, for prices at the retail/consumer level, the average price of rice at consumer level from urban and rural areas is used.

Literature Review

This section will explain the definition of price transmission and Asymmetric Price Transmission (APT) which is expected to exist in the Indonesian rice supply chain. Several types of APT that are important in welfare distribution analysis will be explained. A more detailed explanation of the consequences of differences in speed and magnitude of APT on welfare will be explained. In this section these concepts will be explored from a vertical APT perspective from upstream (farmers) to downstream (retail/consumers) for the rice market. After that, a literature review related to the causes of APT will be explained by focusing more on factors that are more relevant to the case of price transmission along the rice supply chain in Indonesia.

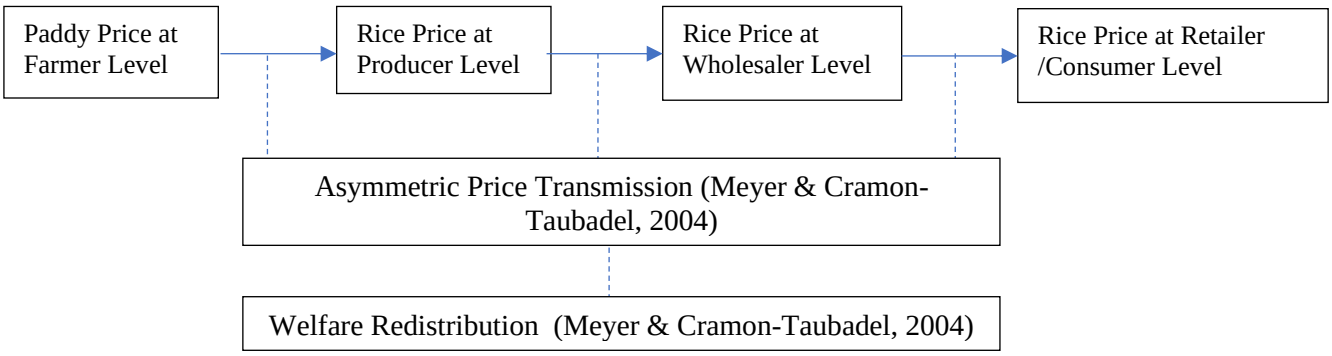


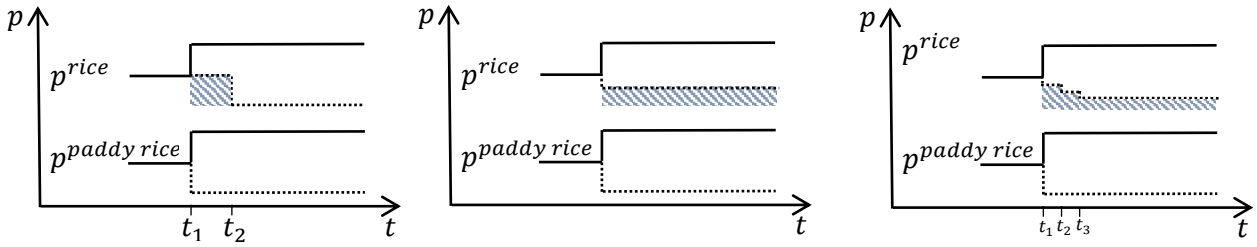
Figure 2.1.1. Research Framework

Vertical price transmission is the response of prices at the downstream level to changes in prices at the upstream level, vice versa (Meyer & Cramon-Taubadel, 2004) . In the rice market, when the analysis is carried out along the supply chain in one direction from upstream to downstream then the price transmission shows price changes at the producer level due to price changes at the farmer level, price changes at the wholesaler level due to price changes at the producer level, as well as price changes at the retailer level due to price changes at the wholesaler level (Heien, 1980) . Furthermore, when price transmission is asymmetric (APT exist), the increasing in prices at the upstream level (farmers/producers/wholesalers) will be responded differently by the prices at downstream level (producers/wholesalers/retailers) compared to when there is a decrease in prices at the upstream level (Meyer & Cramon-Taubadel, 2004; Peltzman, 2000) . Figure 2.1.1 shows price transmission along the supply chain with a one-way direction, from upstream to downstream.

Meyer & Cramon-Taubadel (2004) introduced the APT measurement which is important in welfare distribution analysis. First, price transmission is defined to be asymmetric based on the criteria of speed and magnitude of price transmission. To simplify the interpretation of welfare transfer, modifications on the APT illustration by Meyer & Cramon-Taubadel (2004) have been made for the rice market situation as shown in Figure 2.1.2. The gray area in the figure represent the welfare transfer, assuming constant transaction volume over time (inelastic demand for output). Furthermore, simple interpretation is carried out in one supply

[8]APT analysis actually does not limit price transmission from upstream to downstream, but can also transmit prices from downstream to upstream. However, this research focuses first on price transmission from upstream to downstream.

[9]The existence of price transmission from downstream to upstream, such as the response of farmer prices when there is an increase in prices at the consumer level, is an interesting issue, especially if you want to raise the issue of welfare distribution for farmers. However, this issue is not raised in this research and this research focuses on welfare distribution from upstream to downstream price transmission.



Gambar 2.1.2a. Asymmetric Price Transmission speed
2.1.2b. Asymmetric Price Transmission magnitude
2.1.2c. Asymmetric Price Transmission speed and magnitude
Sumber: Meyer & Cramon-Taubadel (2004)

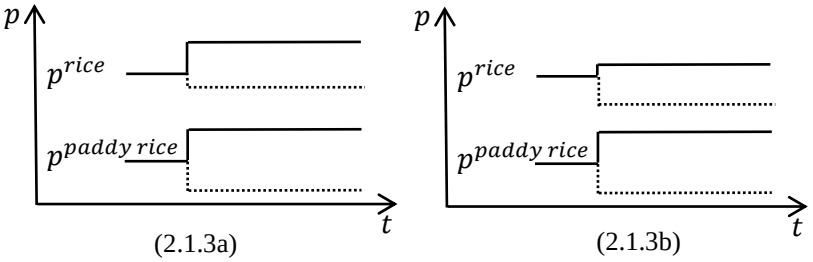
channel, for example from the price of paddy rice at the farmer level (illustrated by p^{in}) to the price of rice at the producer level (illustrated by p^{out}) .

Figure 2.1.2a is the APT in terms of speed or transmission time. This APT occurs when producers do not directly respond to changes in the price of grain at farmers, but the response is carried out within a certain time interval. APT in terms of *speed* will cause temporary welfare transfers between paddy rice farmers and rice producers. In Figure 2.1.2a, the price of rice at the producer level immediately increases along with the increase in the price of paddy rice at the farmer level. However, when there was a decline in the price of paddy rice at the farm level, producers did not directly reduce the price of rice, and the price of rice only fell in the period $(t+1)$. Here, there is a transfer of welfare from paddy rice farmers to rice producers during the time interval from t to $(t+1)$.

Meanwhile, for *the* magnitude or amount of transmission, price transmission is said to be asymmetric when changes in the price of paddy rice at the farmer level are responded with different portions by the price of rice at the producer level. The APT that occurs due to the magnitude will make the transfer of welfare occur permanently (permanent transfer) with the size of the welfare transfer depends on the response to price changes and the volume of transactions carried out (Meyer & Cramon-Taubadel, 2004). In Figure 2.1.1b, the price of rice at the producer level increases as much as the price of paddy rice at the farmer level, whereas when there is a decline in paddy rice prices, the magnitude of the decline in rice prices at the producer level is not as big as the decline in paddy rice prices. Thus, there are indications that there is a permanent welfare transfer from farmers to rice producers.

On the other hand, the combination of speed and magnitude of price transmission also determines whether price transmission is asymmetric or not (Meyer & Cramon-Taubadel, 2004) . In Figure 2.2.2c, when there is an increase in the price of paddy rice at the farmer level , the price of rice at the producer level only responds to the increase in grain $t_2$with perfect transmission, whereas when there is a decrease in the price of paddy rice at the farmer level, the price of rice at the producer level experiences a gradual decline over a period of time $t_2$and $t_3$with a smaller magnitude than a decrease in paddy rice prices or imperfect transmission.

After knowing *th*e speed and magnitude of the APT, this information will be useful for determining the direction of welfare transfers. This is done by determining positive or negative APT based on the criteria developed by Peltzman (2000) in Meyer & Cramon-Taubadel, (2004) . By looking at Figure 2.1.3, price transmission is said to have positive asymmetry (Figure 2.1.3a) when rice prices at the producer level respond



Gambar 2.1.3a Positive Asymmetric Price Transmission
2.1.3b Negative Asymmetric Price Transmission
Sumber: Meyer & Cramon-Taubadel (2004)

more fully/completely or quickly when paddy rice prices increase compared to when paddy rice prices fall. On the other hand, price transmission is said to have negative asymmetry (Figure 2.1.3b) when the rice price response at the producer level is greater (perfect) or faster when the price of paddy rice at the farmer level falls compared to when it rises (Meyer & Cramon-Taubadel, 2004) . From the producer's point of view, positive asymmetry will be better than negative asymmetry (Meyer & Cramon-Taubadel, 2004) . Therefore, it is important to distinguish positive or negative asymmetries that occur in price transmission because the existence of positive and negative asymmetries will determine the direction of *welfare transfers* between players in the market (Meyer & Cramon-Taubadel, 2004) .

In vertical price analysis, APT can occur due to several things. First, the existence of market power in a market as a non-competitive market structure indicates asymmetry (Meyer & Cramon-Taubadel, 2004) . In agriculture, farmers as the starting point and consumers as the final point in the trade supply chain often suspect imperfect competition in the processing industry or intermediary traders which allows abuse of market power (Meyer & Cramon-Taubadel, 2004) . For the Indonesian rice market, this can happen especially when the number of rice producers/milling companies and rice wholesalers is smaller (Ministry of Trade, 2004). This means that wholesalers have a higher market concentration which gives them market power (Kinnucan & Forker, 1987) . In this way, farmers and final consumers will become price takers , while processing industries or wholesalers will be able to determine market prices (price makers) (Conforti, 2004) .

Most research results (Lloyd et al., 2004; McCorriston, 2002; McCorriston et al., 2001) show that conditions of price changes that reduce margins – squeeze the margin (an increase in input prices or a decrease in output prices) will be transmitted more quickly and/or complete compared to price changes that widen the margin – stretch the margin (decrease in input prices or increase in output prices). This means that positive APTs occur more frequently due to market power. However, this condition still cannot be concluded clearly. The existence of market power can also make APT negative if market players who have market power (in this case oligopolies) are afraid to take the risk of losing *market share* when output prices are increased (Ward, 1982).

Another factor that is relevant to the existence of asymmetric price transmission in Indonesia is the existence of government policy towards the rice market (Kinnucan & Forker, 1987) . As previously explained, the government intervenes at both the producer and consumer levels through price controls (both HPP and HET). On the other hand, the government has also begun to implement a limited rice import policy carried out by BULOG based on the results of ministerial level coordination meetings in the economic sector which aims to stabilize prices, especially at the consumer level (based on Ministry of Trade Regulation No. 1 of 2018 and Ministry of Trade Regulation No. 4 of 2012). The existence of imported rice at a lower price means that farmers must be able to compete in selling their paddy rice with imported rice (Putri et al., 2013) . The existence of this policy means that the increase in paddy rice prices at the farmer level may not be fully responded to at the consumer level because it has been dampened by government intervention (Kinnucan & Forker, 1987).

On the other hand, other things that can make price transmission asymmetrical depend on the market structure and the nature of the product (Meyer & Cramon-Taubadel, 2004). When price changes occur in products that do not last long, the price transmission will be faster compared to products that last a long time, such as cereals, which are easier to store (Meyer & Cramon-Taubadel, 2004). However, on the other hand, it is precisely because these products do not last long that traders will hesitate to increase prices for fear that it could reduce sales (Ward, 1982) .

This happens to the Indonesian rice market. Rice crops whose yields are unstable (seasonal) mean that farmers cannot regulate the stock of grain produced (Meyer & Cramon-Taubadel, 2004). Limited infrastructure which is unable to store excess grain production during the main harvest makes farmers sell all their paddy rice production during the main harvest (Yustiningsih, 2012). This means that farmers do not have much power to bargain during the peak harvest season or lean season (Mashitoh, 2019).

Based on this description, to see indications of *welfare transfer* based on price transmission along the rice market supply chain in Indonesia, the hypothesis that will be tested in this research is that there is asymmetric price transmission in terms of speed and magnitude in the Indonesian rice market along the supply chain, namely from (1) farmers to producers; (2) manufacturers to wholesalers; and (3) wholesalers to consumers.

Several studies whose analysis focuses on APT in the rice market use varied empirical method approaches. For APT research on the rice market in Indonesia so far (Hutami, 2018; Laili et al., 2019; Mashitoh, 2019; Novianti et al., 2020; Yustiningsih, 2012) uses the error correction model (ECM) approach developed by Cramon-Taubadel (1998) and Cramon-Taubadel & Loy (1996) . The existence of non-linear price transmission is illustrated by different price adjustments due to positive and negative error correction terms (ECT) (Cramon-Taubadel & Loy, 1996).

Meanwhile, research by Wang & Lee (2009) for the Taiwanese rice market and Deb et al. (2020) for the Bangladesh rice market analyzed the APT using a threshold with the error correction term as the threshold variable. This model was first introduced by Tong (1983) where prices in one market will only respond to price changes in another market when price changes in this other market reach or exceed a certain threshold or vice versa. This modeling is useful when there are indications of adjustment costs in the APT (Meyer & Cramon-Taubadel, 2004). However, the existence of a threshold for error correction according to Meyer & Cramon-Taubadel (2004) cannot be interpreted economically in real markets.

Rahman's (2020) for the Bangladesh rice market used Non-Linear Autoregressive Distributed Lag (NARDL) to analyze the existence of APT. If the use of ECM with asymmetric adjustment terms is only able to capture the speed of time (*speed*) in APT, then NARDL is able to view APT in terms of speed, magnitude, positive or negative (Meyer & Cramon-Taubadel, 2004) . Thus, the approach that can be used to analyze welfare distribution from the presence of APT in the Indonesian rice market is through NARDL.

Empirical Method

Data

To see the transmission of rice prices along the supply chain in Indonesia, data from 2014 to 2021 was used with a monthly period starting from January 2014 to December 2021, which is described in Table 1. Research is conducted at the national level (national aggregate). This is because by looking at price movements in a country where price transmission is monitored at the national level, it can be used as a reference for information on the behavior of producers, consumers and actors therein, especially how they react when there are price changes (Ngango & Hong, 2020). On the other hand, observations at the national level are generally carried out in price transmission studies (Conforti, 2004; Cramon-Taubadel, 1998; Cramon-Taubadel & Loy, 1996; Fousekis et al., 2016; Khotimah, 2013; Kinnucan & Forker , 1987; Laili et al., 2019; Ngango & Hong, 2020; Rahman, 2020; Wang & Lee, 2009; Yustiningsih, 2012)

Table 1. Research Data

No	Data	Unit	Data source
1	Average price of paddy rice at farm level (Dried Unhusked Grain (GKP))	Rp/kg	BPS
2	Average price of medium quality rice at producer level (rice mills)	Rp/kg	BPS
3	Average price of medium quality rice at wholesaler level	Rp/kg	Cipinang Rice Main Market (PIBC)
4	Average price of rice at consumer (retailer) level for urban areas	Rp/kg	Ministry of Agriculture
5	Average price of rice at consumer (retailer) level for rural areas	Rp/kg	BPS

Empirical Model Specifications

To be able to see the transmission of Indonesian rice prices, a dynamic model is used which is a development of the static model Gardner (1975). The difference between static and dynamic models lies in describing the response of prices in one market to price changes in other markets (Pedace, 2013) . The static model means that prices will respond directly at the same point in time (contemporaneous) while the dynamic model includes lag elements from the explanatory variables (Pedace, 2013) .

This dynamic model was chosen because a static approach is more suitable for analysis that only focuses on long-term balance or long run equilibrium (Kinnucan & Forker, 1987) . When the period used is shorter, market disequilibrium conditions can occur which confirm that the market needs time to finally reach equilibrium (Heien, 1980) . This is also in line with the ability to adjust prices when an exogenous shock occurs which requires more than one period point (Brorsen et al., 1985). On the other hand, the inability of static models to capture the nature of time series data will reduce the efficiency of the estimation results and will limit the dynamics of price transmission itself (Brümmer et al., 2009). Thus, static models of price formation are less suitable and it is better to use a dynamic approach (Brorsen et al., 1985; Heien, 1980) .

The use of this dynamic model is also in line with the response of consumer prices to wholesale prices as well as producer and farmer prices, which are generally not direct (instantaneous) but are distributed over

time (there is a lag). This slow response is due to (Kinnucan & Forker, 1987) : (i) the natural conditions of the food-marketing system , especially due to the storage, transportation and processing of agricultural commodities; (ii) the existence of market imperfections such as variations in market structures and differences in the results of information transmission and assimilation at vertical exchange points (farmers-producers-wholesalers-consumers); (iii) the nature of the method of collecting and reporting price data which has a lag (not real time).

To be able to detect the existence of vertical asymmetric price transmission with dynamic data, cointegration analysis is needed. This is because when regressed time series data involves variables that are not stationary (the mean and variance over time are not constant) it often produces spurious regression which implies that the existence of a relationship between variables is not real (Cramon-Taubadel & Loy, 1996) . Spurious regression can be avoided if the variables analyzed are cointegrated (Banerjee et al., 1993 in Cramon-Taubadel, 1998) . Therefore, Cramon-Taubadel & Loy (1996) , which was later developed by Cramon-Taubadel (1998) , using an error correction model (ECM) with the addition of asymmetric adjustment terms which is able to test the existence of asymmetric price transmission.

However, the use of ECM with asymmetric adjustment terms is only able to capture the speed of time in asymmetric price transmission, and not the magnitude (Meyer & Cramon-Taubadel, 2004) . This is because APT which is measured in terms of magnitude shows that there is a permanent difference in response/transmission between positive and negative price changes, so that if a long-term analysis is carried out then the two data that show APT in terms of magnitude will be far away from each other in the long term so that they are not cointegrated (Meyer & Cramon-Taubadel, 2004) .

Therefore, to be able to see APT in terms of speed, magnitude, positive or negative while also accommodating the possibility of price response lag and asymmetric influences, the Non-Linear Autoregressive Distributed Lag (NARDL) model is used . Shin et al. (2014) developed NARDL which is a development of ARDL from Pesaran & Shin (1997) , which can be used to see asymmetric influences through nonlinear asymmetric cointegration . Nonlinear asymmetric cointegration is obtained by including variables that capture nonlinear asymmetric (x_t^+ and x_t^-) (Shin et al., 2014) . Thus, the effect of positive changes in prices (increase in price or p_t^+) as well as the effect of negative changes in price changes (decrease in price or p_t^-) on rice prices at other levels can be estimated in the model.

The use of NARDL has several advantages (Shin et al., 2014) . First, NARDL can examine cointegration relationships with small sample sizes. Second, this model can be used for data whose stationarity is at level-I(0), or at first-difference -I(1). Shin et al. (2014) also added that NARDL is not only able to analyze asymmetries in the short term and long term but also detect hidden cointegration, for example the presence of oil price shocks may have a greater influence in the short term. whereas negative shocks have a greater effect in the long term or vice versa.

There are stages in the NARDL estimation that are used to see the existence of APT in price transmission, referring to Rahman's (2020) research :

a) Checking the stationarity of variables with the unit root test, the aim is to ensure that there are no variables that are stationary at the 2nd order or I(2)
b) Cointegration testing, using the bound test approach
c) Formation of positive and negative variables to see asymmetric relationships.
d) Model formation NARDL
e) Testing the existence of asymmetric influences.
f) Dynamic multiplier analysis

As previously explained, Shin et al. (2014) decompose values x_t into positive (x_t^+) and negative (x_t^-), i.e

$$x_t = x_0 + x_t^+ + x_t^- \quad (3.2.1)$$

with

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \quad (3.2.2)$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \quad (3.2.3)$$

Then, asymmetric long run regression is

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \mu_t \quad (3.2.4)$$

Where $y_t$and $x_t$are variables that are at least stationary in I(I) ;β^+ and $\beta^-$is the asymmetric long run parameter of x_t^+andx_t^+

After that, Shin et al. (2014) built a general NARDL model as follows.

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^+ x_t^+ + \theta^- x_t^- + \sum_{j=1}^{p-1} \lambda_i \Delta y_{t-j} + \sum_{j=1}^{q-1} \delta_j^+ \Delta x_{t-j}^+ + \sum_{j=1}^{q-1} \delta_j^- \Delta x_{t-i}^- + \varepsilon_t \quad (3.2.5)$$

Based on model (3.2.6), by making $y_t$is the input or upstream price; $x_t$is the output or downstream price and refers to Fousekis et al. (2016) and Rahman (2020) , the equation used to see the existence of asymmetric price transmission in the rice market in this research is as follows.

Farmers→ Producer

$$\Delta lpp_t = \alpha_1 + \rho_1 lpp_{t-1} + \theta_1^+ lpf_{t-1}^+ + \theta_1^- lpf_{t-1}^- + \sum_{j=1}^{p_1-1} \lambda_{1j} \Delta lpp_{t-j} + \sum_{j=0}^{q_1-1} \pi_{1j}^+ \Delta lpf_{t-j}^+ + \sum_{j=0}^{q_1-1} \pi_{1j}^- \Delta lpf_{t-j}^- + e_{1_t} \quad (3.2.\ 6a)$$

Producer →Wholesaler

$$\Delta lwp_t = \alpha_2 + \rho_2 lwp_{t-1} + \theta_2^+ lpp_{t-1}^+ + \theta_2^- lpp_{t-1}^- + \sum_{j=1}^{p_2-1} \lambda_{2j} \Delta lwp_{t-j} + \sum_{j=0}^{q_2-1} \pi_{2j}^+ \Delta lpp_{t-j}^+ + \sum_{j=0}^{q_2-1} \pi_{2j}^- \Delta lpp + e_{2_t} \quad (3.2.\ 6b)$$

Farmers→ Wholesaler

$$\Delta lwp_t = \alpha_3 + \rho_3 lwp_{t-1} + \theta_3^+ lpf_{t-1}^+ + \theta_3^- lpf_{t-1}^- + \sum_{j=1}^{p_1-1} \lambda_{3j} \Delta lwp_{t-j} + \sum_{j=0}^{q_1-1} \pi_{3j}^+ \Delta lpf_{t-j}^+ + \sum_{j=0}^{q_1-1} \pi_{3j}^- \Delta lpf_{t-j}^- + e_{3_t} \quad (3.2.\ 6c)$$

Retailer→ Wholesaler

$$\Delta lcp_t = \alpha_4 + \rho_4 lcp_{t-1} + \theta_4^+ lwp_{t-1}^+ + \theta_4^- lwp_{t-1}^- + \sum_{j=1}^{p_3-1} \lambda_{4j} \Delta lcp_{t-j} + \sum_{j=0}^{q_3-1} \pi_{4j}^+ \Delta lwp_{t-j}^+ + \sum_{j=0}^{q_3-1} \pi_{4j}^- \Delta lwp_{t-j}^- + e_{4_t} \quad (3.2.\ 6d)$$

Farmers→ Retailer

$$\Delta lcp_t = \alpha_5 + \rho_5 lcp_{t-1} + \theta_5^+ lpf_{t-1}^+ + \theta_5^- lpf_{t-1}^- + \sum_{j=1}^{p_1-1} \lambda_{5j} \Delta lcp_{t-j} + \sum_{j=0}^{q_1-1} \pi_{5j}^+ \Delta lpf_{t-j}^+ + \sum_{j=0}^{q_1-1} \pi_{5j}^- \Delta lpf_{t-j}^- + e_{5_t} \quad (3.2.\ 6e)$$

With lpf is the price of paddy rice (GKP) at the farmer level; lpp is the price of rice (medium quality) at the milling level; lpw is the price of rice at the wholesaler level; and lpr is the price of rice at the retailer level for rice commodities (which is calculated from the average price of rice for consumers in urban and rural areas). All variables were transformed in natural logarithmic form. Next t denotes the period; while j=1,…(p_1-1);j=1,…(q_1-1); j=1,…(q_3-1);j= 1,…(p_2-1),1;j=1…(q_2-1);j= 1,…(p_3-1), is the optimal lag of each model with optimal lag values for each variable may vary.

The lag order will be determined based on a general-to-specific model approach, where variables will be selected that are considered capable of explaining the relationship between variables in the model optimally (Shin et al., 2014). In this research, the model specification starts with max q = max p = 6 and then variables that are not significant (based on the t-test at α=5%) will be removed from the model. Thus, even though in the general NARDL model specification the lag j on positive and negative variables is the same, referring to Shin et al (2014) and Fousekis et al (2016), the final model estimates may show different lags on positive and negative variables according to significance. respective variables. The aim of forming this model is to avoid mis-specification in forming the estimation model, especially if an insignificant lag variable is included in the model, it will increase the inaccuracy of the model estimation results and can result in unstable dynamic multipliers (Fousekis et al., 2016; Rezitis, 2019; Shin et al., 2014). After the model is formed, a stability test of the model is carried out using cumulative sum (CUSUM) testing.

Next, testing the existence of APT which is the hypothesis in this research was carried out. To test the first hypothesis in the model, namely that there is asymmetric price transmission in terms of speed and magnitude , we tested the existence of short-term and long-term APT. Short-term analysis is used to compare the intensity of variations in output prices due to positive or negative changes in input prices (Frey & Manera, 2007) . Meanwhile, long-term analysis is needed if empirical research specifically wants to calculate reaction times, duration of fluctuations, and the speed of adjustment towards equilibrium (Frey & Manera, 2007) .

APT in terms of magnitude shows the response of output prices which are influenced by changes in input prices (Gervais, 2011) . The existence of APT in terms of magnitude is interpreted by the difference in output price response between when there is an increase and a decrease in input prices in the long term (Fousekis et al., 2016) . This is what makes APT in terms of magnitude show the existence of permanent [10]welfare transfers (Meyer & Cramon-Taubadel, 2004) . Therefore, the hypothesis that there is asymmetric price transmission in terms of magnitude is tested using the Wald test. The null hypothesis is $\mathrm{H}_0 = \beta_\mathrm{i}^+ = \beta_\mathrm{i}^-$where $\beta_\mathrm{i}^+ = -\theta_\mathrm{i}^+/\rho_\mathrm{i}$and $\beta_\mathrm{i}^- = -\theta_\mathrm{i}^-/\rho_\mathrm{i}$where $\mathrm{i} = 1, 2, 3, 4, 5$respectively represent price transmission from farmers to producers (equation 3.2.6a); producers to wholesalers (equation 3.2. 6b); farmer to wholesaler (equation 3.2.6c); wholesalers to retailers (equation 3.2.6d); and farmers to retailers (equation 3.2.6e).

In Meyer & Cramon-Taubadel (2004) , it is explained that APT in terms of *speed* shows the difference in the first response time of *output prices* when there is an increase and decrease in *input prices,* which In terms of measurement, it will depend on the length of the time interval required to respond to changes in *input prices* between $t_1$up to and t_{1+n}according to Figure 2.1.2(a) and (c). As stated previously, APT in terms of *speed* shows the speed of response of *output prices* which are influenced by changes in input prices (Gervais, 2011) . If adapted to the concept of Meyer & Cramon-Taubadel (2004) , the APT measurement in terms of *speed* can be tested based on the significance of differences in short-term parameter estimates using *the Wald test* (Fousekis et al., 2016) . The null hypothesis is $H_0 = \beta_i^+ = \beta_i^-$where $\beta_i^+ = -\theta_i^+/\rho_i$and $\beta_i^- = -\theta_i^-/\rho_i$where $i = 1, 2, 3, 4, 5$respectively represent price transmission from farmers to producers (equation 3.2.6a); producers to wholesalers (equation 3.2.6b); farmer to wholesaler (equation 3.2.6c); wholesalers to retailers (equation 3.2.6d); and farmers to retailers (equation 3.2.6e).

If it is statistically proven that there is an APT in terms of speed and magnitude, then there is an indication of welfare transfer between Indonesian rice market players. Furthermore, to see the direction of *the* welfare transfer, it is necessary to see whether the APT is positive or negative. To calculate the positive or negative APT, it is necessary to compare the coefficient values of each model, namely (Fousekis et al., 2016; Kamaruddin et al., 2021; Rahman, 2020) :

1. A positive APT occurs if the magnitude $\beta_\mathrm{i}^+ > \beta_\mathrm{i}^-$ with $\mathrm{i} = 1, 2, 3, 4, 5$ each representing price transmission from farmers to producers (equation 3.2.10a); producers to wholesalers (equation 3.2.10b); farmer to wholesaler (equation 3.2.10c); wholesalers to retailers (equation 3.2.10d); and farmers to retailers (equation 3.2.10e).
2. A negative APT occurs if the magnitude $\beta_\mathrm{i}^+ < \beta_\mathrm{i}^-$ with $\mathrm{i} = 1, 2, 3, 4, 5$ each representing price transmission from farmers to producers (equation 3.2.10a); producers to wholesalers (equation 3.2.10b); farmer to wholesaler (equation 3.2.10c); wholesalers to retailers (equation 3.2.10d); and farmers to retailers (equation 3.2.10e).

Results and Analysis

Before NARDL estimation is carried out, variable stationarity testing and model cointegration testing are carried out. Based on the DF-GLS test results, all variables are stationary at *the first difference,* or integrated at the 1st degree ($\mathrm{I}(1)$) so that analysis using the NARDL model can be carried out.

The results of cointegration testing equations (3.2.10a) to (3.2.10e) in Table 4.2.3 show that the null hypothesis which states that no cointegration occurs is rejected in $\alpha = 5\%$.Thus, it can be concluded that there is cointegration between the price of grain at the farmer level and the price of rice at the farm level. producers, producer-level rice prices with wholesalers, farmer-level grain prices with wholesaler-level rice prices, wholesaler-level rice prices with retailers, and farmer-level grain prices with retailer-level rice prices. This means that, although in the short term prices at the farmer level (producer/wholesale trader) and prices at the producer/wholesale trader/retailer level (wholesale trader/retailer) move differently, in the long term both prices will converge to a similar behavior. The same.

[10]Explanation of Figure 2.1.2b

Table 4.2.1 Data Stationarity Test Results with DF-GLS

Variable	DF-GLS τ *Test Statistics*	*Critical Value*	
		$\alpha = 1\%$	$\alpha = 5\%$
lfp	-1,248 (11)	-3,595	-2,771
lpp	-1,189 (11)	-3,595	-2,771
lwp	-1,214 (10)	-3,595	-2,804
lcp	-0.568 (11)	-3,595	-2,771
Δlfp	-5,509*** (2)	-3,599	-3,029
Δlpp	-6,937*** (1)	-3,599	-2,802
Δlwp	-5,618*** (4)	-3,599	-2,982
Δlcp	-6,915*** (1)	-3,599	-3,048

*Optimal lag selection is based on Ng-Perron sequential t and Ng-Perron modified Akaike information criterion (MAIC) which are provided in brackets. The **, *** signs respectively indicate significance at$\alpha = 5\%$ dan 1%*

Source: BPS, PIBC (processed)

Table 4.2.3 *Bound Test* Testing Cointegration of Price Transmission Along the Supply Chain

Statistics NARDL	NARDL model (3.2.10a) Producer Farmers→	NARDL model (3.2.10b) Manufacturer →Wholesaler	NARDL model (3.2.10c) Wholesaler Farmers→	NARDL model (3.2.10d) Wholesaler Retailer→	NARDL model (3.2.10e) Retailer Farmers→
F_{PSS}	15.4994***	9.4077***	8.5944***	4,1934***	15.8882***

*Critical value based on Pesaran et al. (2001) with $k = 1$on$\alpha = 5\%$ (1%) ForF_{PSS} the lower bound and upper bound are 4.94 – 5.73 (6.84 – 7.84). The **, *** signs respectively indicate significance at$\alpha = 5\%$ dan 1%*
Source: BPS, PIBC (processed)

The existence of asymmetric price transmission can be seen from the transmission of grain prices at the farmer level to rice prices at the producer level. This is based on the Wald Test for long run asymmetry significant at $\alpha = 5\%$. Thus, in terms of magnitude as seen based on long-term asymmetric parameters, a 1% increase (decrease) in the price of paddy rice on farmers is responded by producers with an increase (decrease) in the price of rice of around 0.84% (0.82%) in the long term. However, in the short term the existence of APT from farmers to producers has not been proven. Even though the estimation results show that short-term APT is not proven, the speed of price adjustments (speed) at the producer level when price changes/shocks occur at the farmer level can still be observed through dynamic multipliers (Shin et al., 2014) .

The speed and pattern of adjustment to a new equilibrium from rice producers is almost the same when a shock occurs in the form of an increase/decrease in grain prices at the farm level. Both increases and decreases in grain prices require producers around 17 months to adjust and reach a new stable condition (equilibrium). However, during these 17 months, the speed of response from producers has reached around 50% of the price increase adjustment process in the 8th-9th month (around 44%-50%). Meanwhile, the speed of response to price reductions reached 50% of the adjustment process occurring in the 9-10th month (around 48%-55%). This means that producers respond more quickly when there is an increase in the price of farmer's grain, especially in the initial period compared to a decrease in the price of farmer's grain, even though in the end both the increase and decrease in rice prices take the same time to reach a new equilibrium.

Based on the estimation results and dynamic multiplier that have been described, although not large, there is an indication that producers dominate compared to paddy rice farmers in Indonesia. If we look at the situation of farmers and millers in Indonesia, one mill usually purchases paddy rice from many farmers (on average in one rice production center location there are around 57 farmers and only 4 mills) so that there is an oligopsony pattern in this condition (LPPM- IPB , 2018) . This can make producers as price makers while farmers as price takers (Rapsomanikis et al., 2004). Based on qualitative research conducted by LPPM-IPB (2018) and Widyarini et al. (2016) , this condition occurs because most farmers sell their grain in GKP condition, while the grain that is ready to be milled into rice is GKG, or dried GKP. Farmers do not have warehouses to store their harvested grain or sufficient land to dry the grain until it becomes GKG, whereas these facilities are

owned by producers (rice mills) so that rice mills have a stronger position and can determine the price of the grain they buy from farmers.

Table 4.2.4 NARDL Estimation Results for the Rice Price Transmission Equation at the Producer and Wholesaler Level

NARDL model (3.2.10a) producer farmers→		NARDL model (3.2.10b) wholesaler manufacturers→		NARDL model (3.2.10c) wholesale farmer→	
Variable	Coefficient (se)	Variable	Coefficient (se)	Variable	Coefficient (se)
$constant$	3.1093*** (0.4816)	$constant$	3.9340*** (0.7472)	$constant$	3.8136*** (0.6463)
lpp_{t-1}	-0.3438*** (0.0533)	lwp_{t-1}	-0.4393*** (0.0834)	lwp_{t-1}	-0.4225*** (0.0717)
lfp^{+}_{t-1}	0.2880*** (0.0439)	lpp^{+}_{t-1}	0.3434*** (0.0911)	lfp^{+}_{t-1}	0.2529*** (0.0589)
lfp^{-}_{t-1}	0.2790*** (0.0427)	lpp^{-}_{t-1}	0.2703*** (0.0926)	lfp^{-}_{t-1}	0.2172*** (0.0564)
Δlpp_{t-1}	0.3194*** (0.0601)	Δlpp^{+}_{t}	0.8920*** (0.1780)	Δlwp_{t-1}	0.2738*** (0.0952)
Δlfp^{+}_{t}	0.3066*** (0.0745)	Δlpp^{+}_{t-2}	0.7934*** (0.1831)		
Δlfp^{-}_{t}	0.2850*** (0.0536)	Δlpp^{-}_{t}	0.6218*** (0.2111)		
Δlfp^{-}_{t-2}	-0.1337** (0.0601)				
Asymmetric long-run price transmission parameters					
$\beta^{+}_{lfp\_p}$	0.8378***	β^{+}_{lpp}	0.7816***	$\beta^{+}_{lfp\_w}$	0.5987***
$\beta^{-}_{lfp\_p}$	0.8116***	β^{-}_{lpp}	0.6152***	$\beta^{-}_{lfp\_w}$	0.5140***
Asymmetric Test					
lfp *Long run*	2.85*** (0.006)	lpp *Long run*	17.39*** (0.000)	lfp *Long run*	5,391*** (0.000)
Short runs	1.40 (0.234)	*Short runs*	3.48* (0.0654)	*Short runs*	-
Statistics & Diagnostics					
R^2_{adj}	0.7603		0.5604		0.2978
F-Statistics	42.69*** (0.00)		20.54*** (0.00)		10.86*** (0.00)
Heteroscedasticity	9.2918 (0.2324)		6.6217 (0.3573)		6.9293 (0.1397)
Serial Correlation	0.1150 (0.9441)		1.2302 (0.2826)		2.1886 (0.3348)
Ramsey Reset	3.907* (0.0514)		1.8801 (0.1739)		2.5080 (0.1169)
CUSUM	*stable*		*stable*		*stable*

*Note: se= standard error; In Asymmetric test and Statistics & Diagnostics , statistical values and p-values are displayed in brackets. Heteroscedasticity test with the Harvey-Godfrey test; Serial Correlation with the Breusch-Godfrey LM test. $\beta_{lfp_p}$from farmer prices to producer prices while $\beta_{lfp_w}$from farmer prices to wholesaler prices; The signs *,**,*** respectively indicate significance at$\alpha = 10\%, 5\%\ dan\ 1\%$*
Source: BPS, PIBC (processed)

This asymmetric existence can also be related to the government's HPP policy. Producers, in this case millers, will think that when the price of grain falls, the price decline is only temporary because there will be intervention from the government to stabilize the falling price of grain again (Kinnucan & Forker, 1987). Thus, producers choose not to lower prices too far (Kinnucan & Forker, 1987).

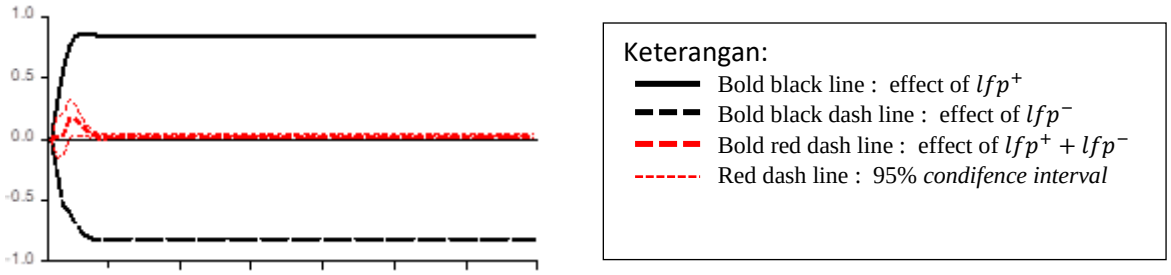


Figure 4.2.1 Dynamic multiplier of Producer Rice Prices against Farmers' Paddy Rice Price Shocks
Source: BPS (processed)

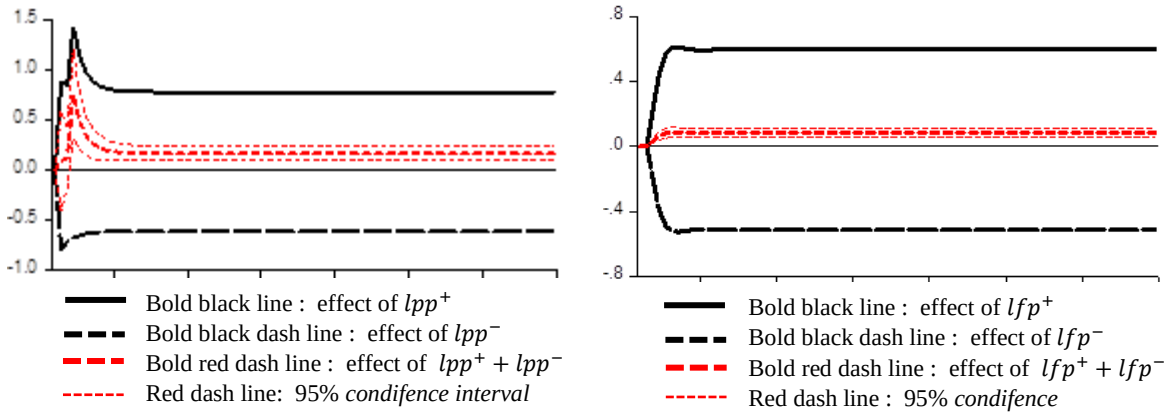
Wholesalers respond to changes in rice prices at the producer level asymmetrically. This is based on the estimation results in Table 4.2.4 which shows that APT was found significantly in the long term ($\alpha = 5\%$) and short term ($\alpha = 10\%$). Based on the estimated value of price transmission parameters, in magnitude, increase (decrease) The price of rice at the producer level by 1% will make the price of rice at the wholesaler level increase (decrease) 0.78% (0.62%) in the long term. The difference in response from wholesalers is quite large when there is an increase/decrease in rice prices at the producer level, namely around 0.17%.

Furthermore, in terms of speed and pattern of adjustment towards a new equilibrium, there are differences in the response of wholesalers when there is an increase and decrease in the price of rice at producers. This is based on the dynamic multiplier in Figure 4.2.2 (a). When there is an increase (decrease) in producer prices, wholesalers need an adjustment period of around 18 months (15 months) to finally arrive at a new stable/equilibrium condition. During the price adjustment process, wholesalers have responded up to 50% of the increase in rice prices in a period of 12-13 months, whereas when prices decrease, it takes 11-12 months to reach around 50% of the adjustment process to the new stability. This means that wholesalers make price adjustments for a shorter period when there is a decrease in the price of rice at the producer level, and actually increase the price of rice for a longer time when there is an increase in the price of producer rice.

Based on the estimation results and dynamic multiplier analysis, wholesalers have a better position than rice producers. This is also confirmed by literature (Meyer & Cramon-Taubadel, 2004; Peltzman, 2000; Vavra et al., 2005) which sees the existence of middlemen who have large market power to be able to determine prices. In Indonesia, rice producers sell their rice directly to wholesalers located in rice production centers or in big cities, where producers also experience a position where there are only a few rice wholesalers on the market (LPPM-IPB, 2018) . Producers usually only sell to wholesalers who are used to buying their rice (LPPM-IPB, 2018) . Here, wholesalers determine the purchase price of rice from producers because wholesalers have storage warehouses with much larger capacity and are able to absorb rice from many producers both within and outside their region (LPPM-IPB , 2018) . On the other hand, wholesalers supply rice to many retailers as well as to smaller wholesale traders (Widyarini et al., 2016) .

On the other hand, the existence of this APT can also occur due to the existence of wholesalers' cost menus. The use of cost menus (for example, the cost of reprinting sacks) makes wholesalers prefer to hold the price of rice so that it does not fall when prices decrease at the producer level because the costs will be much greater for the wholesalers (Ball & Mankiw, 1994) . In such cases, wholesalers will prefer to respond to increases in producer prices with larger price increases compared to when there is a decrease in producer prices (Ball & Mankiw, 1994) .

Information regarding price changes at the farmer level that reach wholesaler in the long term is proven. This can be seen from the estimation results (Table 4.2.4) which show that APT does occur in the long term. However, in the short-term adjustment process, price information at the farm level is still not used directly by wholesalers. In terms of magnitude, a 1% increase (decrease) in the price of farmers' grain will be transmitted to wholesalers' rice prices increasing (falling) by 0.60% (0.51%).



(a) (b)

Figure 4.2.2 Dynamic multiplier of Wholesaler Rice Prices against Shocks (a) Producer Rice Prices; (b) Price of Farmer's Paddy Rice

Source: BPS (processed)

Furthermore, the speed and adjustment pattern can be seen through the dynamic multiplier (Figure 4.2.2 (b)). Wholesalers react to changes in prices at the farmer level in the 2nd month to the 22nd (21st) month when there is an increase (decrease) in the price of farmer's grain. To arrive at a 50% response towards new stability, wholesalers need around 11-12 months when there is an increase or decrease in farmers' grain prices. This could occur as a result of price transmission which is not perfectly transmitted from farmers to producers when prices fall so that it continues to wholesalers and makes the asymmetry even higher (Meyer & Cramon-Taubadel, 2004) .

Furthermore, between wholesalers and retailers, retailers also respond asymmetrically to price changes at the wholesale level. This can be seen from the estimation results (Table 4.2.5) which show the significance of the existence of APT both in the short and long term. In terms of *magnitude,* in the long term, retailers respond to a 1% price increase from wholesalers by increasing the price of rice by around 0.64%, whereas when there is a 1% decrease in rice prices at wholesalers, the response from retailers is only to reduce it by 0.50%.

However, the adjustment pattern of retailers is slightly different from the adjustment of rice traders at other levels. If we observe the dynamic multiplier in Figure 4.2.3 (a), retailers adjust by reducing prices at a higher rate compared to increasing the price of rice in the initial price adjustment period. Furthermore, retailers little by little begin to increase prices higher than when lowering prices so that in the long term, there is still dominance of retailers who can prevent prices from falling.

Table 4.2.5 NARDL Estimation Results for the Rice Price Transmission Equation at the Retailer Level

NARDL model (3.2.10d) wholesalers →retailers		NARDL model (3.2.10e) retailer farmers→	
Variable	Coefficient (se)	Variable	Coefficient (se)
$constant$	2.7037*** (0.6019)	$constant$	1.8745*** (0.4127)
lcp_{t-1}	-0.2949*** (0.0658)	lcp_{t-1}	-0.2033*** (0.0450)
lwp^+_{t-1}	0.1884*** (0.03506)	lfp^+_{t-1}	0.1372*** (0.0244)
lwp^-_{t-1}	0.1474*** (0.0306)	lfp^-_{t-1}	0.1193*** (0.0216)
Δlcp_{t-6}	0.2132*** (0.0791)	Δlcp_{t-1}	-0.2510*** (0.0949)
Δlwp^+_t	0.2058*** (0.0539)	Δlcp_{t-5}	-0.1915*** (0.0876)

Δlwp_t^-	0.2721*** (0.0664)		
Asymmetric long-run price transmission parameters			
β_{lwp}^+	0.6388***	β_{lfp}^+	0.6750***
β_{lwp}^-	0.4999***	β_{lfp}^-	0.5863***
Asymmetric Test			
lwp *Long run*	4,564*** (0.000)	lfp *Long run*	4,308*** (0.000)
Short runs	0.698 (0.4874)	*Short runs*	-
Statistics & Diagnostics			
R_{adj}^2	0.4670		0.3537
F-Statistics	13.85*** (0.00)		10.74*** (0.00)
Heteroscedasticity	5.6501 (0.4635)		2.8598 (0.7216)
Serial Correlation	2.4747 (0.2901)		1.7020 (0.1920)
Ramsey Reset	0.1003 (0.7523)		1.8698 (0.1759)
CUSUM	*stable*		*stable*

*Note: se= standard error; In Asymmetric test and Statistics & Diagnostics, statistical values and p-values are displayed in brackets. Heteroscedasticity test with the Harvey-Godfrey test; Serial Correlation with the Breusch-Godfrey LM test. The signs *,**,*** respectively indicate significance at* $\alpha = 10\%, 5\%$ *dan* 1%
Source: BPS, PIBC (processed)

Then, looking at the speed of response, the adjustment time required by retailers to reach a new equilibrium condition is around 34 months (35 months) when there is an increase (decrease) in the price of rice at wholesalers. Approximately 50% of adjustments have been made in the first 18-19 months (first 17-18 months) of the price adjustment period. This means that retailers choose to respond more quickly when there is an increase in prices and a little longer when there is a decrease in the price of rice at retailers.

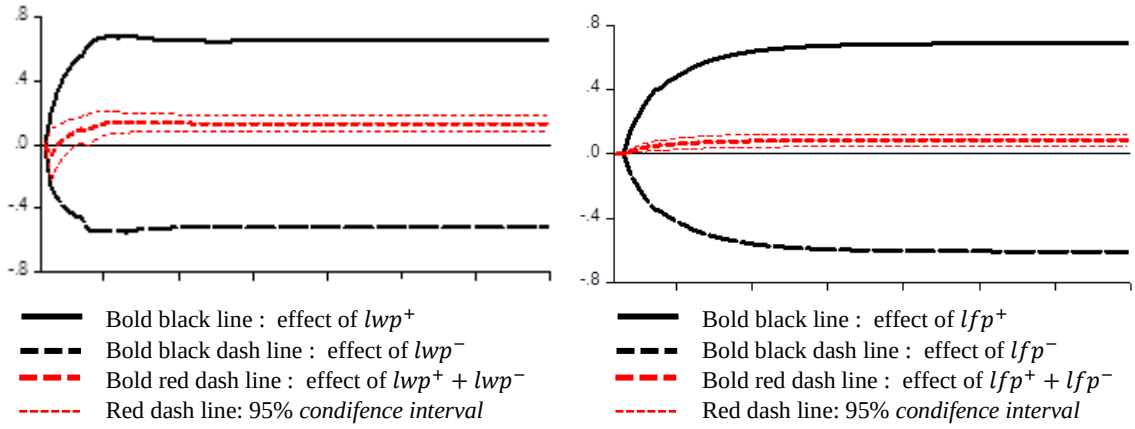


Figure 4.2.3 Dynamic multiplier of Retailer Rice Prices against Shocks (a) Wholesaler Rice Prices; (b) Price of Farmer's Grain
Source: BPS (processed)

The existence of asymmetric price transmission in the rice market at the retailer level in the long term can occur due to the inelastic nature of demand for rice prices relative to changes in rice prices. The existence of rice as a staple food in Indonesia makes retailers respond quickly to information about rising grain prices and respond weakly when there is a decline in rice prices (Chou & Lin, 2019) . However, in the short term, retailers try to lower prices to be able to compete in the market, considering that the market structure at the retailer level is competitive (Mardianto et al., 2005) .

Price changes at the farmer level can be passed on to retailer, but not perfectly. This can be seen from the estimation results (Table 4.2.5) which show that APT only occurs in the long term. This means that in the short-term adjustment process, price information at the farm level is still not used directly by retailers, whose

conditions are the same as wholesalers. In magnitude , a 1% increase (decrease) in the price of farmers' grain will be responded to by retailers by increasing (decreasing) the price of rice by 0.68% (0.59%).

Furthermore, the speed and adjustment pattern can be seen through *the dynamic multiplier* (Figure 4.2.3 (b)). Retailers only started to react to changes in prices at the farm level in the 2nd month to the 64th (72nd) month when there was an increase (decrease) in the price of farmer's grain. To reach a 50% response to new stability, retailers need around 35-36 months (40-41 months) when there is an increase (decrease) in farmers' grain prices. This could occur as a result of price transmission which is not perfectly transmitted from farmers to producers and then to wholesalers, so that even at retailers the asymmetry becomes higher (Meyer & Cramon-Taubadel, 2004) .

Discussion of Welfare Distribution Indications

Information from *Asymmetric Price Transmission* based on previous estimation results can be used to see indications of the existence of *welfare distribution* among economic actors along the Indonesian rice market supply chain. In Meyer & Cramon-Taubadel (2004) , it is stated that the existence of APT indicates that there are certain groups who do not gain *benefits* (faster or greater) from price reductions (buyers) or price increases (sellers) that can be obtained under symmetrical conditions. Long-term APT (in this case *magnitude*) can occur because of the existence of *market power* , where the existence of this *market power* will be used to increase *the economic profit* of the agent, and from here the APT of *magnitude* can explain *the welfare implications* (Meyer & Cramon-Taubadel, 2004) .

If seen in general terms, the magnitude of the price decline at the starting point of the supply chain, namely the farmer level, cannot be fully enjoyed by consumers as the final point in the rice market, when compared to when there is an increase in grain prices at the farmer level. This is proven based on the existence of positive *asymmetric price transmission* in the long term, namely an increase in grain prices at the farm level which is responded to more quickly and significantly by retailers compared to when there is a decline in grain prices.

The decrease in the price of grain at the farmer level, when compared with the increase in the price of grain at the farmer level, which is not fully enjoyed by rice consumers, could indicate that there are other economic actors who receive *benefits* from the reduction in grain prices. Therefore, further identification at each stage of the supply chain is carried out to see at what point *the benefits* or *welfare* received by other economic actors should reach consumers. This identification first begins by observing the estimation results which show the existence of APT, especially in the long term, then looking at the direction of *welfare transfer* based on the positive or negative APT (Meyer & Cramon-Taubadel, 2004) that has been found. Next, an analysis of the estimated scheme for the amount of *benefit* or *welfare transfer* from transactions of 1 kg of rice between agents is carried out due to increases/decreases in grain prices at the farmer level.

With the illustration of a 10% increase (decrease) in the price of grain (IDR 466.82/kg) at the farmer level, profits The largest is obtained by wholesalers from transactions of 1 kg of rice. This is based on the analysis of Table 4.2.7 which shows that when the price of grain at the farm level rises (falls) 10% (10%) (IDR 467,-/kg) then producers will increase (decrease) 8.38% (8.11%).) (IDR 761,-/kg vs IDR 738,-/kg) price of rice. This was then responded to by wholesalers, namely when producers increased (lowered) the price of rice per kg by 8.38% (8.38%) (IDR 761,-/kg) then wholesalers increased (lowered) 6.55% (5 .15%) (IDR 599,- /kg vs. IDR 472,- /kg) whereas when producers reduce (increase) the price of rice by 8.11%(8.11%) (IDR 738,- /kg) then wholesalers reduce (increase) 4.993%(6.34%) (IDR 457,- /kg vs. IDR 581,- /kg). Furthermore, at the retailer level, an increase (decrease) in the price of wholesale rice by 6.55% (IDR 599,-/kg), then the price of rice at the retailer level will increase (decrease), whereas when wholesale traders increase (decrease) the price of rice was 4.993% (IDR 457,-/kg) then retailers responded by increasing (lowering) the price of rice by 3.19% (2.50%) (IDR 351,-/kg vs. IDR 274,-/kg).

Based on this illustration, if it is assumed that the ideal condition is symmetrical price transmission with a symmetrical response value based on the price reduction coefficient, then the agent who creates the highest profit due to market power (when compared to when conditions are symmetrical) is a wholesaler. Firstly, producers are not really able to create high prices for their rice so the additional profit due to the APT is only IDR 23,- for every 1 kg of rice transactions with wholesalers. Meanwhile, if in ideal conditions wholesalers would increase/decrease prices by IDR 457,- from an increase/decrease in rice prices of IDR 738,- /kg producers, then due to the market power that wholesalers have, wholesalers will actually increase their rice prices *to* IDR 581,- for every kg of rice. This shows that an additional profit of IDR 124/kg was created by wholesalers. Furthermore, if in ideal conditions retailers will increase/decrease the price of rice by IDR 274,- /kg due to an increase/decrease in the price of rice by IDR 457,-/kg at retailers, then because retailers still

have a better position compared to consumers, retailers will increase IDR 76, -/kg is higher when there is an increase in rice prices at wholesalers. Thus, every agent starting from producers, wholesalers and traders creates additional profits from every increase in the price of rice they buy, with the largest profit creation being made by wholesalers.

In the end, the results of the estimation of the existence of APT that have been described indicate two things. First, an indication of the existence of welfare loss from consumers. This is because consumers cannot gain profits of the same magnitude as the reduction in prices at the farm level because retailers are able to hold back prices so that they do not fall as much as the decrease in grain prices at the farm level. Second, behind consumer welfare losses , there are wholesalers who are indicated to have received the largest welfare gains among large market players along the supply chain. This comes from the welfare transfer obtained by wholesalers for their dominance, which is able to hold prices so that they do not fall as much as prices at the producer level and are able to create a better position when transacting with retailers.

In this research, the welfare distribution discussed in the discussion is an indication obtained from asymmetric price transmission information. To get a better and more precise understanding of the amount of welfare distribution, a comprehensive method that goes beyond price transmission analysis is needed. The implications of price changes on welfare can be analyzed using methods such as consumer surplus or equivalent/compensating variation if you want to look at it from the demand side/ consumer side or supply function estimation if you want to look at it from the supply side/ producer side, the results of which also depend greatly on the market structure itself. (Darbandi, 2018; Rahman, 2020) .

Conclusion

Conclusion

This research aims to see the existence of APT in the transmission of rice prices along the supply chain in Indonesia. To answer this goal, the NARDL model is used which is able to capture asymmetric price transmission (APT). Specifically, the use of NARDL will be able to estimate differences in speed and magnitude of rice price transmission which are triggered from price changes at the farmer level to price changes at the retailer level (which reflects the final consumer). Based on this information, this research will explain the possibility of welfare distribution from price changes at the farmer level.

Between farmers and producers, there is a slight dominance of producers compared to farmers. This can be seen from the magnitude of price transmission which shows a greater response of producer prices to increases in farmer prices when compared to decreases in farmer prices in the long term. Meanwhile, in terms of speed , it shows that both increases and decreases in farmer prices are responded to at the same speed until they finally reach a new equilibrium. This better position of producers indicates that there is welfare transfer with slightly greater benefits obtained by producers.

Furthermore, between producers and wholesalers, wholesalers gain quite large dominance. The existence of a positive APT, namely that the response from wholesalers to an increase in the price of rice at the producer level is faster and greater when compared to when there is a decrease in the price of rice at the producer level, confirmed based on the estimation results. Meanwhile, in terms of speed , it shows differences in the speed of adjustment towards the long term, with longer adjustments occurring when there is an increase in producer prices. Here we can see that there is a welfare transfer to wholesalers (from retailers) because the wholesalers are in a better position to be able to regulate their rice prices so that they do not fall too much when there is a decline in rice prices.

The same thing also happens between farmers and wholesalers, namely the dominance of wholesalers is quite high when compared to the position of farmers. In the long term, wholesalers do respond to both increases and decreases in grain prices, but this also occurs asymmetrically where the price decline due to the decline in grain prices is able to be tolerated quite well by wholesalers. Meanwhile, in terms of speed of response to adjustments, increases in farmer prices were responded to longer than decreases in farmer prices.

Furthermore, between wholesale traders and retailers, retailers have slightly different adjustment patterns. In the short term, retailers respond to a decrease in wholesaler prices higher than an increase in rice prices at wholesalers. However, as time went by, retailers began to increase their rice prices, so that in the long term the ability of retailers to control rice prices did not fall too much when there was a decline in rice prices at wholesalers. Meanwhile, in terms of speed of adjustment, a decrease in rice prices at wholesalers was responded to longer than when there was an increase in prices at wholesalers. The existence of APT indicates

that retailers gain more benefits from consumers because in the long term retailers are able to control prices so that they do not fall too much.

There are changes in prices from the farmer level to the retailers. Even though in the short term retailers do not respond to changes in prices at the farmer level, in the long term, retailers respond to information about increases in the price of grain from farmers by increasing the price of rice to a greater extent compared to when there is a decrease in grain prices. In terms of speed of adjustment, the increase in grain prices took longer to respond to compared to when there was a decline in farmers' grain prices.

In the end, the results of the estimation of the existence of APT that have been described indicate two things. First, an indication of the existence of welfare loss from consumers. This is because consumers cannot gain profits of the same magnitude as the reduction in prices at the farm level because retailers are able to hold back prices so that they do not fall as much as the decrease in grain prices at the farm level. Second, behind consumer welfare losses , there are wholesalers who are indicated to have received the largest welfare gains among large market players along the supply chain. This comes from the welfare transfer obtained by wholesalers for their dominance, which is able to hold prices so that they do not fall as much as prices at the producer level and are able to create a better position when transacting with retailers.

One of the important implications of explaining the existence of APT in this research is regarding the welfare of the farmers themselves. In this case, farmers as the first point of the supply chain do not actually receive welfare transfers from market players at different distribution levels, where in this research only positive APT was found, which indicates a greater response when there is a price increase compared to a price decrease. A decrease in prices at the farmer's point which is not fully transmitted to the consumer could be detrimental to the final consumer.

Research Limitations

This research does not include spatial Asymmetric Price Transmission , which analyzes price transmission at the same level in different regions. It cannot be denied that spatial APT is also an interesting price transmission research for further study. In discussing price transmission, spatial price transmission or also called horizontal transmission (Vavra et al, 2005) focuses more research, especially on the theory of The Law of One Price, which is mostly related to determining exchange rates (at the national level) or market integration (Vavra et al, 2005) .

However, to be able to carry out spatial analysis, especially for Indonesia, price data with a deeper coverage is needed with analysis on one type of product with the same quality. To be able to obtain information about trading partners and trade patterns between regions which can be different from each other. area will be quite challenging for researchers. Therefore, this research focuses on vertical price transmission , namely price transmission at different price levels for the same commodity, which focuses on the existence of price efficiency itself among rice market players.

On the other hand, this research does not add control variables to the price transmission equation. This is because this research follows a non-structural approach where the main focus of this research is to look at the existence of price transmission itself. Basically, in price transmission research, Rapsomanikis et al., (2004) introduced two approaches, namely non-structural approach and structural approach.

The non-structural approach considers the factors that determine price transmission as initial information on the existence of price transmission itself. In other words, price transmission testing will be interpreted as an attempt to see the extent of the existence of these factors, for example in specific cases such as the efficiency of a market (Rapsomanikis et al., 2004) . In the non-structural approach analysis, the analysis will focus more on dynamic analysis of price movements which then develops to look at the cointegration relationship between prices in the two markets (Rapsomanikis et al., 2004) . The existence of this cointegration will show that prices in the two markets do have different behavior in the short term but they will converge to the same behavior in the long term (Rapsomanikis et al., 2004) .

In contrast to the non-structural approach whose main aim is to look at the existence of price transmission, the structural approach tries to explicitly explain the behavior of price transmission by presenting factors that influence the amount of price transmission in its analysis (Rapsomanikis et al., 2004) . Price transmission research using a structural approach focuses more on industrial economics applications, which emphasizes, for example, the impact of market power, or increasing returns to scale in the production function on the size of price transmission, such as research by McCorriston et al. (2001) .

Apart from that, analysis of the impact of a policy on price transmission is also included in the structural approach. To examine the impact of a policy on price transmission Rapsomanikis et al. (2004) consider that policy simulation is needed in their analysis which requires a group of variables that represent a policy and cannot easily use simple price transmission parameter estimates. The structural approach analysis itself requires the use of more specific and detailed data, compared to just aggregate price data (for example, average commodity prices as in this research).

Therefore, this research still focuses on analyzing price transmission through estimating price transmission parameters. The analysis in this research does have its own advantages and disadvantages. The parameter estimates produced in dynamic analysis using a non-structural approach may have lower values than they should (low parameters) because the value of the estimated parameters themselves can actually still be influenced by other factors that influence the magnitude of price transmission (Rapsomanikis et al., 2004) . Furthermore, the resulting parameter estimate value will always be smaller than one, even though, for example, the price transmission that occurs is actually complete (transmitted perfectly) (Rapsomanikis et al., 2004) .

Even though there are shortcomings, there are still several advantages to the approach used in this research. The value of the parameter estimates and the resulting significance will provide information on which markets also experience shocks if prices in other markets are shaken, or in other words which markets behave consistently (well-functioning markets) in terms of the ability of prices to be transmitted (Rapsomanikis et al. , 2004) . This also shows that the resulting parameter estimates can summarize the overall effect of the factors that influence price changes, including transaction costs, the existence of market power, product diversity in the market, and policy changes (Rapsomanikis et al., 2004) .

Suggestion

Suggestions that can be given regarding the research results:

1. Based on the results of estimates and dynamic multiplier analysis, the greatest welfare gain occurs at wholesale traders, so the government can consider conducting further exploration and intervention so that welfare among rice market players is distributed evenly.
2. This research uses price data at the retailer level (consumer prices) for all types of domestic rice quality (premium, medium and high quality). Future rice price transmission research could consider using consumer price data that focuses on one quality only.
3. This research still analyzes price transmission from upstream to downstream in one direction. Further research development can be carried out by analyzing two-way price transmission from upstream to downstream and vice versa.
4. Considering that this research still covers vertical price transmission, further research could consider a more comprehensive and in-depth analysis by examining horizontal/spatial price transmission.
5. This research does not cover the factors that influence the transmission of rice prices in Indonesia. The explanations given in the discussion of this research are still preliminary indications collected based on theoretical and empirical reviews from other research which could be one of the causes of asymmetric price transmission, the significance of which has not been proven statistically. Therefore, future research can carry out further exploration with research based on *a structural approach.*

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