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Price transmission between GMO-free organic and conventional milk in Austria

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Abstract

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This study investigates a milk price relationship between organic and conventional milk in Austria. We employ a vector error correction model, Johansen co-integration, and threshold co-integration test to establish whether organic and conventional milk markets are integrated and have asymmetric price relationships. Our results show no existence of threshold co-integration compared to linear co-integration. Our findings also present a price leadership of organic on conventional milk in a long-run. In a short-run, our results indicate while organic milk price has a positive effect on conventional milk price, conventional milk price does not have a significant effect on conventional one price.

Keywords: organic milk; price transmission; Vector error correction model; Threshold co-integration test

Introduction

Production and consumption of organic food in the European Union (EU) have increased in the past decade due to an increase of the demand of specific consumers who value sustainability, environment, and animal welfare (EU, 2019). Consequent to these phenomena, the organic farming area in the EU has increased more than 70% during the last ten years, reflecting that cultivating methods in the EU have been rapidly changed (EU, 2019). Considering that organic farming productivity is much lower than the conventional one (EU, 2019), this rapid change in cultivating method is expected to total agricultural output as well as production share between organic and conventional agricultural products. Thus, the shift from conventional to organic farming will decrease total agricultural products without a rise in the farming area. In other words, an increase of organic farming is associated with supply change of organic, conventional, and total agricultural goods. In addition, consumers pay more on organic foods compared to conventional one (Hasselbach & Roosen, 2015; Krystallis et al., 2006), which implies the demand shift from organic to conventional agricultural products. In turn, an increase in organic farm production and consumption is expected to affect both prices of conventional and organic agricultural goods significantly (Table 1).

Recently few studies have investigated those price relationships in the EU areas to address a possible change of price relationship between conventional and organic agricultural products from a shift in production and demand of organic farm goods. Würriehausen et al. (2015) explore a price relationship between organic and conventional wheat in Germany utilizing a Markov-switching asymmetric vector error correction model. Kleemann & Effenberger (2010) focus on a price relationship between organic and conventional pineapple in EU with considering spatial dependency. Kleemann & Effenberger (2010) and Würriehausen et al. (2015) present that conventional prices have more effects on organic prices than organic prices on conventional ones. More recently, An-

Table 1. Supply and demand shock and prices of organic and conventional foods

	Specific Factors	Organic Price	Conventional Price
Demand Shock	– Preference for Organic↑	+	–
Supply Shock	– Organic Area↑	–	+
	– Conventional Area↓	+	+
	– Total Output ↓ : Due to low productivity of organic farming compared to conventional farming	+	+

tonioli et al. (2019) and Dolgopolova & Roosen (2018) examine the asymmetric price relationship in Italy's milk sector and newly adapted non-GMO certification in Germany's milk sector, respectively.

These previous approaches for the price relationship between organic and conventional foods are useful to understand the market structure between those two markets. By figuring out the market structure, these empirical studies give some policy or marketing implications. For example, if conventional food has a price leadership on organic one, then we can conclude that a conventional market has a dominant position on organic one. In this case, retail marketers' optimal strategy might be set the price premium on organic based on conventional food. If organic food has a price leadership on conventional one, the decision question for conventional farmers will be the choice of shift from conventional to organic farming. It is because the organic market has a dominant position over the conventional market. In turn, production shift from conventional to organic farming might not guarantee a high organic food price due to this product shift is expected to decrease a price of organic food. In this case, the choice of farmers should depend on the expected price of organic food considering the possible change of organic food from the production shift from conventional to organic food in the national level.

However, previous studies for organic and conventional agricultural product price transmission did not cover Austria's agricultural products. Previous price transmission literature for Austria only has focused on vertical price transmission (Fernández-Amador et al., 2010). However, Austria is one of the fast-growing countries in organic farming in the EU. Specifically, Austria's organic production and organic milk volume shares are the highest among EU countries in 2017 (EU, 2019). Additionally, Austria's increased amount of organic milk between 2012 and 2017 is most elevated among EU countries (EU, 2019).

This study aims to analyse a price relationship between organic and conventional milk in Austria using the monthly data from January 2017 to October 2020, by utilizing the vector error correction model (VECM) and impulse-response analysis, considering both short-run and long-run aspects. By performing these analyses, this paper is expected to derive several results which are useful to improve the understanding the Austrian milk market and derive some policy implications. Results of Granger causality test provide a price leadership between organic and conventional milk and we can figure out a long-run and short-run adjustment between two prices based on results of VECM and impulse-response analysis. Additionally, we also test the threshold co-integration versus linear co-integration to check asymmetric price transmission in Austria's organic and conventional milk prices. This asymmetric price relationship approach allows us to test the existence of market power between those two markets since the asymmetric price transmission reflects the market power according to Simioni et al. (2013). If the price transmission is faster during a price rising period rather than a price declining period, there might exist the market power (Meyer & Cramon-Taubadel, 2004).

Our approach is expected to fill a gap in previous literature for price transmission between organic and conventional agricultural products in EU countries. First, organic and conventional milk price relationship in Austria have not been examined even though Austria's increase of organic milk production and demand is one of highest countries in EU based on authors' best knowledge. Second, Austria is an excellent sample to estimate the price transmission between organic and conventional milk without considering importing foreign ones. Austria has the highest tariff rate (533% in 2018) in milk among EU countries, which implies that the milk market of Austria is actually protected from the import market[1]. Third, we can cover the issues for price transmission between high-quality agricultural products since Austria produce only non-GMO milk (EU, 2019). Non-GMO products are perceived as safe foods by consumers (Dolgopolova & Roosen, 2018) and non-GMO milk can be considered to be of higher quality compared to GMO milk. Most consumers also believe organic foods are healthier (Petrescu & Petrescu-Mag, 2015), allowing them to consider organic milk as higher quality milk than conventional ones.

Literature Review

Previous studies for organic and conventional products can be divided by two criteria which are regions and existence

[1] Please see: https://oec.world/en/profile/hs92/milk#:~:text=Tariffs %3A%20In%202018%20the%20average, %2C%20and%20 Iceland%20(145%25).

of asymmetries. To be specific, empirical literature for organic and conventional agricultural goods is divided by European countries and United States. This classification is important since European and U.S. consumers' interest for organic food is high. The second criteria is testing asymmetries, which reflects the existence of market power (Simioni et al., 2013).

Previous articles such as Antonioli et al. (2019), Dolgopolova & Roosen (2018), Kleemann & Effenberger (2010), and Würriehausen et al. (2015) have examined the relationship between organic and conventional foods in European countries. Among these literature, Dolgopolova & Roosen (2018) and Kleemann & Effenberger (2010) do not focus on testing asymmetries between organic and conventional prices. Dolgopolova & Roosen (2018) explore the impact of "GMO-free" labeling based on GMO regulations (EC/ 1829/2003) on the price relationship among conventional, GMO-free milk, and organic milk in Germany. Their findings based on VECM show that organic milk and GMO-free milk in Germany have a long-run relationship. Kleemann & Effenberger (2010) focus on spatial pineapple price dependency between organic and conventional in the market of Europe. Their results present that there is a price premium on organic compared to conventional pineapples due to high price dependency of organic on conventional pineapples.

Studies such as Antonioli et al. (2019) and Würriehausen et al. (2015) have tested the asymmetric price relationship between organic and conventional food in Europe. Antonioli et al. (2019) investigate the price transmission between conventional and organic fluid milk in Italy. They use Momentum-Threshold autoregressive model and find the non-existence of symmetric price transmission in milk market of Italy. Utilizing the vector error correction model (VECM), they find the speed of adjustment is higher in conventional milk rather than organic one. Würriehausen et al. (2015) investigate the price relationship between organic wheat and conventional wheat in Germany. They find the asymmetric price relationship between two prices using a flexible Markov-switching model.

There are few existing empirical studies for the price relationship between organic and conventional agricultural goods in United States. Studies such as Kim et al. (2019) and Nemati & Saghaian (2018) focus on the test of asymmetric price transmission between organic and conventional agricultural products of United States. Kim et al. (2019) explore a price relationship between organic and conventional vegetables focusing on carrot, lettuce, and tomato. Using Nielsen scanner data during weekly period from 2006-2015 and several time series methods such as a threshold vector error correction model, threshold vector autoregressive model, and threshold co-integration test method, they find that existence of asymmetries and a long-run relationship depends on vegetable characteristics. Nemati & Saghaian (2018) investigate a price relationship between organic and non-organic apples in United States. They divide apples to Galal, Fuji, and Red Delicious and find asymmetries in all tested apple prices.

On the other hand, previous empirical approach such as Singerman et al. (2014) examine the co-integrated relationship between organic and conventional foods itself in United States. Singerman et al. (2014) find that there is no long-run relationship between organic and conventional crops in United States. Based on this result, they argue that organic crop price determination in U.S. is independent to the conventional crop market. Their results based on spatial co-integration test among crop markets in U.S. show that organic crop markets' spatial co-integrated relationship is stronger than conventional crop markets' relationship.

Data and Method

Data

Data on farm-gate organic and conventional milk in Austria is gathered from CLAL.it that uses AgrarMarkt data. Our monthly data is from January 2017 to October 2020. Table 2 illustrates the farm-gate prices of organic and conventional milk in Austria. All these milk products are non-GMO since Austria only produces non-GMO milk. As we expected, the average price of organic dairy is higher than conventional milk in Austria. Considering that price reflects product quality as perceived by consumers, organic milk has higher quality than conventional one.

Table 2. Descriptive Statistics

	Organic Milk Price with Hay Milk	Conventional Milk Price
Mean	50.21	32.94
Standard Deviation	2.12	1.60
Max	56.46	36.84
Min	47.42	29.90

Note: Price (Euro/100Kg)

Unit Root and Johansen Co-integration Tests

For the price analysis, this study uses the natural log of each price data. This paper uses the Phillips–Perron (PP) test of Phillips and Perron (1988) and Kwiatkowski et al. (1992) to test the stationary. PP test addresses the augmented Dickey–Fuller test's serial correlation problem (Phillips & Perron 1988). The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root test is utilized in our study as it is complementary with the PP test due to the opposing null hypothesis between KPSS and PP tests (Chen & Saghaian 2016).

This study utilizes the Johansen co-integration test based on trace statistics. This enables us to check the co-integration relationship between monthly farm-gate organic and conventional milk prices in Austria. This paper begins with a vector autoregressive model to explain the Johansen co-integration test as the following equation:

$$P_t = \mu + \sum_{n=1}^{k+1} \Pi_n P_{t-n} + \varepsilon_t \quad (1)$$

where P_t is a 2 × 1 milk price vector that is composed of organic and conventional milk, and μ and Π are 2 × 1 constant and parameter vector, respectively. ε_t is the error term with the assumption of i.i.d. normal and the number of lags is $k + 1$. Equation 1 can be rewritten as the error correction form as the following equation (Chen & Saghaian, 2016).

$$P_t = \mu + \Pi P_{t-1} \sum_{n=1}^{k} \Gamma_n \Delta P_{t-n} + \varepsilon_t, \quad (2)$$

where Γ_k is defined as $-\sum_{j=k+1}^{p} \Pi_j$.

The long-run matrix Π is written as $\Pi = \Pi_1 + \Pi_1 + ... + \Pi_k - I$ and decomposed into $\alpha\beta'$. α for adjustment vector of 2 × r indicates the speed of adjustment of organic and conventional prices toward long-run equilibrium. Here, r presents the cointegration rank. r × 2 co-integration vector, β, represents the long-run linear relationship among prices of organic and conventional. The Johansen co-integration test can derive the co-integration rank that reflects the number of co-integration vectors. Specifically, the rejection of null hypothesis is that the co-integration rank is 0 indicating no co-integration in prices between organic and conventional. In other words, if the null of $r = 0$ is rejected, then prices of organic and conventional milk have a long-run relationship. If $r = 0$ is rejected, we have to test whether $r = 1$ or not. This procedure will be continued; the null hypothesis of co-integration rank is not rejected.

Vector Error Correction Model (VECM) and Hansen & Seo (2002) Test

Based on the existence of co-integration relationship between organic and conventional milk in Austria, ΠP_{t-1} in the equation 2 for the error correction model can be rearranged by $\alpha\beta' P_{t-1}$. $\beta' P_{t-1}$ shows the period $t - 1$'s deviation from the long-run equilibrium and stands for the error correction (Chen and Saghaian 2016). By doing t-test for coefficients of α, we also can check for long-run causality since this t-test indicates a long-run weak exogeneity tests introduced by Granger (1988) (Chen and Saghaian 2016). According to Motamed et al. (2008), this long-run causality based on a long-run weak exogeneity test can be considered a price leadership. α and Γ indicate a speed of adjustment in a long-run and a temporary price-adjustment effect term, respectively (Chen & Saghaian 2016).

We also test the threshold co-integration for checking a possible asymmetry in the relationship between organic and conventional milk prices in Austria. This study employs Hansen & Seo (2002) threshold co-integration test method called a supreme Lagrange Multiplier (*sup*-LM) test method to examine the threshold co-integration. To explain the *sup*-LM test method, we begin with a threshold vector error correction (TVECM) model as the following equation.

$$\Delta P_t = \begin{cases} \mu_p + \alpha_{PL} ECT_{L,t-1} + \Pi_1 \Delta P_{t-1} + \cdots + \Pi_1 \Delta P_{t-p} + \varepsilon_t, & ECT_{t-1} \le v \\ \mu_p + \alpha_{PH} ECT_{H,t-1} + \Pi_1 \Delta P_{t-1} + \cdots + \Pi_1 \Delta P_{t-p} + \varepsilon_t, & ECT_{t-1} > v \end{cases} \quad (3)$$

where L and H are a lower price regime and high price regime, respectively. v is the threshold value to ECT_{t-1} for dividing high and low price regimes. Other subscriptions and notations follow equation 2. The null hypothesis for the *sup*-LM test is that the price relationship between organic and conventional milk in Austria is linear VECM. The alternative hypothesis is that those price relationships are TVECM. For doing the *sup*-LM test, Hansen & Seo (2002) employ the grid search method. Additionally, Hansen and Seo (2002) also utilize a bootstrap approach due to no prior information for the *sup*-LM test distribution.

Results

Table 3 reports the PP and KPSS unit root test results. Prices of organic milk are non-stationary based on both tests at the 10% significance level. On the other hand, prices of conventional milk have unit-root according to the PP and KPSS tests. However, all first difference milk prices are stationary based on PP and KPSS tests. These results represent a possible unit-root at the data of level prices.

Table 3. Stationary Tests Results

	Level		First Difference	
	PP	KPSS	PP	KPSS
Ln(Organic milk)	-2.15	0.35*	-4.36 ***	0.08
Ln(Conventional milk)	-2.51	0.08	-3.92 ***	0.10

Notes: ***, **, and * present 1%, 5%, and 10% significance level, respectively. While the null hypothesis of PP is that series of price data are non-stationary, the null hypothesis of KPSS is that price series are stationary. This study tests unit-root based on the only intercept case since all milk prices do not show the deterministic time trend

Table 4 shows the Johansen co-integration test results between organic and conventional milk prices based on trace statistics. The null hypothesis, the no-co-integration relationship between organic and conventional milk, is rejected at the 10% significance level. However, the null hypothesis that the minimum rank of that priced integration is 1 is rejected at the 10% significance level. In turn, prices between organic and conventional milk in Austria has a long-run relationship with a rank = 1.

Table 4. Results of Johansen Co-integration Test

	$r = 0$	$r = 1$
Organic Milk-Conventional Milk	19.15*	6.84

Notes: * denotes 10% significance level. The null hypothesis of is that prices of organic and conventional milk do not have a long-run relationship. 1%, 5%, and 10% critical values of are 24.60, 19.96, and 17.85, respectively. The null hypothesis of is that prices between organic and conventional milk have a cointegration rank 1. The critical values of 1%, 5%, and 10% for the null hypothesis are 12.97, 9.24, and 7.52, respectively

Table 5 reports the results of the *sub*-LM test for threshold co-integration test. There is no threshold co-integration over liner co-integration at the 10% significance level. In turn, using a VECM model is more appropriate than TVECM model. There is one possible explanation for the nonexistence of threshold co-integration in Austria's farm milk market. Simioni et al. (2013) pointed out asymmetric price transmission reflecting some market power evidence typically originated from monopoly power. According to Meyer & Cramon-Taubadel (2004) if price is transmitted faster during the period when a price rises compared to when a price decreases, then the existence of market power is highly suspicious. However, most of Austria's milk farm size is very small at both cases of organic and conventional farms, which implies that Austrian organic and conventional farmers are less likely to have market power[2]. In turn, no existence of threshold co-integration relationship between two milk prices is explainable.

Table 5. Results of *Sub*-LM Test

Test Statistics	P-Value	Critical Value		
		90%	95%	99%
10.3	0.6	14.42	15.54	18.04

Notes: We perform 1,000 bootstrap replications since there is no prior information for *sub*-LM Statistics distribution

Table 6 represents the vector error correction model (VECM) between organic and conventional milk prices in Austria. The coefficient of the speed of adjustment (α) in the equation of traditional price of milk is 0.1678 at the 10% significance level. This result indicates that each period's conventional milk price deviation from a long-run equilibrium is 16.78%. Simultaneously, the coefficient of the speed of adjustment in organic milk price does not become significant at the 10% significance level. This result implies that organic milk price is not adjusted into the long-run equilibrium based on the price relationship between organic and conventional milk. In turn, we can conclude that organic milk price has a price leadership on the conventional milk price in Austria based on the weak exogenous test result. Our results also imply that organic and conventional milk markets in Austria are not fragmented even though organic milk is perceived as a high-quality product compared to conventional dairy by consumers.

One more important result of Table 6 is the estimated co-integration vector. Our estimated co-integration vector means that a 1% increase of organic milk price leads a 1.12% increase in the conventional milk price in a long-run. While organic milk production has increased, conventional one has decreased, affecting a higher price effect than organic price shock. While traditional milk price positively impacts organic milk price in a short-run, organic milk price does not affect conventional milk. This result means that the Austria milk market has a price premium of organic on conventional milk in a short-run.

Table 6. Results of VECM

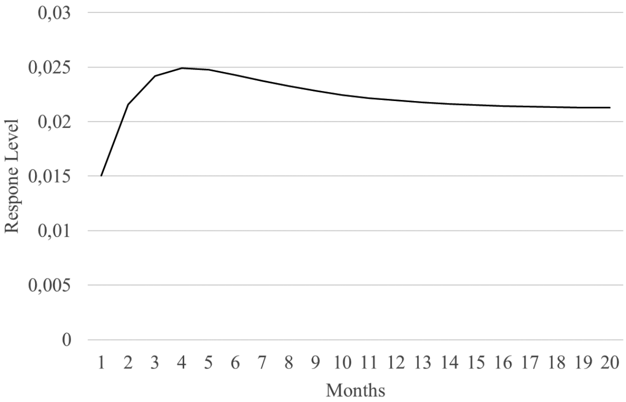
	$\Delta Ln(p_{organic,t})$	$\Delta Ln(p_{conventional,t})$
Co-integration vector	(1 -1.121)	
ECT_{t-1}	0.0088	0.1678*
	(0.0858)	(0.0921)
Intercept	-0.001	0.0015
	(0.0027)	(0.0029)
$\Delta Ln(p_{organic,t-1})$	-0.1453	-0.0799
	(0.2849)	(0.3057)
$\Delta Ln(p_{conventional,t-1})$	0.5163 **	0.5266*
	(0.2488)	(0.2670)

Notes: * and ** denotes 10% and 5% significance level, respectively

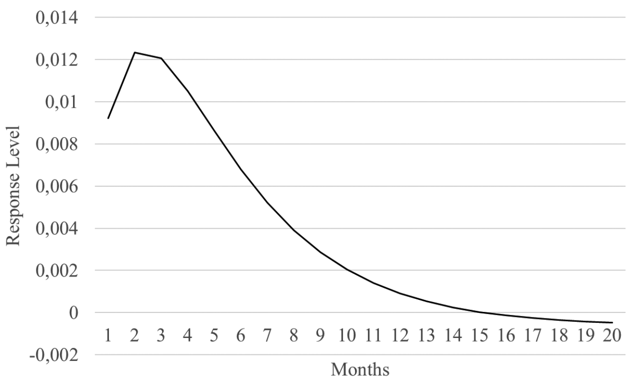
Our analysis results might reflect the characteristics of the milk market in Austria. Organic milk production has increased with substituting to a production reduction on conventional milk in Austria. Due to higher milk productivity in conventional milk than the organic one, a production shift from conventional to organic dairy is expected to have negatively affected total milk production in Austria. Additionally, consumer preferences for organic milk have increased for the recent decade. To sum up, the current demand and supply-side changes in the Austria milk market are driven by organic milk rather than a conventional one. In turn, a long-run price leadership of organic on conventional milk might represent this Austria market situation.

[2] According to Dairy Focus 07/2018 of European Dairy Association, the average milk cow per farmer is 20.

Figure 1 displays organic milk price shock on the conventional one and its impact on organic one. This impulse-response method is appropriate for analysing dynamic effects. Like the positive sign of the adjustment speed, organic milk price shock on conventional milk price does not entirely die. Specifically, the shock of organic milk price on conventional one has rapidly increased until 4 months and decayed until about 12 months. After that period, organic milk price shock on the conventional one has not decreased. On the other hand, the price impact of conventional milk on organic one is died out completely. Specifically, a price shock of conventional milk on organic one has reached a peak after 2 months. After that, conventional milk's price shock on organic milk has rapidly decreased and almost wholly died around 14 months. These results also strongly support the results of VECM. According to the results of VECM, organic milk price has a long-run price leadership on conventional milk price, and the positive sign for speed of adjustment coefficient indicates that organic milk price shock on conventional one will not disappear. Our results also show the short-run positive effect of conventional milk price on organic one, which indicates that conventional milk impact on organic milk price, will be diminished.



Ln(Organic Milk Price) on Ln(Conventional Milk Price)



Ln(Conventional Milk Price) on Ln(Organic Milk Price)

Fig. 1. Impulse responses

Conclusion and Policy Implications

This study investigates a price relationship between organic and conventional milk in Austria, utilizing the monthly data from January 2017 to October 2020. This research topic is timely since organic milk has rapidly substituted conventional milk in Europe for a decade, and this substitution trend is expected to be expanded. Since Austria is one of fast production transforming from conventional to organic milk, we have focused on Austria's milk market and is not likely affected by imported milk due to the highest milk tariff rate (533% in 2018) in Europe. Specifically, we have examined the integration of organic and conventional milk markets. Furthermore, this study also tests the existence of asymmetric price transmission.

Our results show that there is no asymmetric price relationship between organic and conventional milk in Austria. The lack of market power might explain this result in both organic and conventional milk farmers. According to the European Dairy Association, the milk farm's size is very small at both cases of organic and conventional farms: the average size of milk farm is 20 cows in 2018. Johansen co-integration test results show a long-run relationship between conventional and organic milk prices in Austria. Specifically, the estimation results of VECM present a positive long-run price relationship between two types of milk. 1% increase in organic milk price has an impact on more than 1% increase in conventional milk price according to the estimated co-integration vector. Based on the significance of ECT term, we also found that organic milk price has a price leadership on conventional milk price in a long-run. On the other hand, conventional milk price positively affects organic milk price in a short-run. The impulse-response function results present, while organic milk's price shock on conventional milk does not entirely disappear. A price impact of conventional milk on organic one completely vanishes around 14 months later.

Findings of this study contribute to previous literature and given some important implications. First, our results fill a gap in existing studies related to conventional and organic price relationships since no empirical papers explore the milk market in Austria even though Austria is fast-shifting from conventional to organic milk in Europe. Second, our findings suggest that organic milk has a price leadership on conventional milk in Austria. This result is expected to reflect the milk market characteristics in Austria. The organic milk demand has increased for a decade, and conventional milk production is substituted by organic milk. The organic milk market structure change leads to a change in the conventional milk market in Austria. Third, the expansion of organic milk production might cause to increase the overall milk price level. The general milk price level is expected to be increased, especially in conventional than organic milk, considering the lower production shift from conventional to organic milk, high tariff barriers in the milk market, and co-integration vector results.

This study only focuses on the organic and conventional milk price relationship to capture the recent production shift from conventional to organic milk and enhanced preference for organic milk of consumers in Austria. Our results imply that this production shift causes an increase in milk prices asymmetrically. In turn, future work should consider this milk production shift dynamic effect on organic and milk farmers' profits to find the optimal organic and conventional milk production in Austria to maximize the welfare of Austrian milk farmers. The future study also should examine the consumer welfare effect from this production shift.

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