

**The Derived Demand for Imported Cheese in Hong Kong Differentiated by Source
Country of Production**

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In this recent decade Hong Kong has emerged as a significant dairy importer. Currently, Hong Kong is ranked 11th among dairy importing countries for whey and 7th for whole milk powder. This was up significantly from the 1980's when Hong Kong ranked 31st and 37th for whey and whole milk powders respectively. For butter, cheese, and non-fat dry milk, Hong Kong ranks 22nd, 34th, and 27th respectively (FAO Statistics). The driving force behind Hong Kong's emergence as a major dairy importer is phenomenal growth in per-capita consumption resulting from economic expansion. Also, Hong Kong is heavily influence by western culture and it has become a major re-exporter of dairy products to other Asian countries. At present, Hong Kong's share of world dairy imports is 1.44 percent, which is twice its import share in 1990 (FAO Statistics).

The major goal of this paper is to provide the U.S. dairy industry with empirical estimates of the sensitivity (elasticities) of Hong Kong's derived demand for imported cheese differentiated by source country of production with respect to price changes and total import changes. These estimates will then be used to assess the relative competitiveness of cheese imported from the U.S. to cheese imported from other source countries. Past studies that assessed the demand for imports differentiated by source country of production have used a utility or consumer approach to obtain import demand equations. However, given that imported dairy products are purchased by firms, and that a significant amount of transformation and/or value added takes place after goods reached the importing country, this study will estimate demand from a production approach where imports are inputs into production processes.

Specific goals are: (1) To econometrically estimate the derived demand for imported cheese in Hong Kong; (2) To utilize the empirically estimated import demand parameters to provide

empirical measures of the sensitivity of demand to changes in total imports, own price, and the prices of cross country substitutes; and (3) To estimate the effects of export subsidy reductions on the derived demand for cheese in Hong Kong.

Methodology

The econometric model that will be used to estimate the derived demand for imported cheese into Hong Kong is the differential factor allocation model (DFAM), this model is

$$\bar{f}_{it} D x_{it} = \theta_i D X_t + \sum_{j=1}^n \pi_{ij} D w_{jt} + \varepsilon_{it}. \quad (1)$$

$Dx_t = \log(x_t) - \log(x_{t-1})$ and $Dw_t = \log(w_t) - \log(w_{t-1})$ are the log change in quantity and price respectively from period $t-1$ to t , where x_i and w_i are respectively the quantity and price of Hong Kong's imported cheese from source country i . $\bar{f}_{it} = (f_{it} + f_{it-1})/2$, where f_i is the i th factor share of total cost. DX is the finite version of the Divisa input index, where $DX_t = \sum_{i=1}^n \bar{f}_{it} D x_{it}$. π_{ij} 's are the price coefficients and θ_i is the marginal share of the i th input in marginal cost. Both are parameters to be estimated.

A key feature of the DFAM is that production theory can be tested or imposed upon the system to determine if the data is consistent with theory. The properties, homogeneity and symmetry are imposed and tested, and negative semi-definiteness is checked by inspection of the eigen values of the price coefficient matrix. The homogeneity property in the DFAM model is satisfied when $\sum_j \pi_{ij} = 0$. Symmetry is satisfied when $\pi_{ij} = \pi_{ji}$ (Washington, 2000).

When applied to the estimation of the derived demand for cheese imports into Hong Kong, equation (1) is the i th derived demand equation for imported cheese into Hong Kong from exporting country i , where $i \in$ (US, Oceania, EU, ROW). ROW is the rest of the world, which in

this instance is an aggregation of all imports of cheese into Hong Kong not imported from the US, Oceania, or the EU. Oceania is an aggregation of Australia and New Zealand. The Divisa input index is now an index of total cheese imports into Hong Kong. f_i is the total cost of cheese from source country i divided by the total cost of all cheese imported into Hong Kong. w_i 's are the prices for imported cheese charged by the exporting countries. x_i is the quantity of cheese imported into Hong Kong from the i th exporting source.

Estimation of the system of equations represented by equation (1) will be accomplished using the LSQ procedure in the econometric program package Time Series Processor (TSP), version 4.4. The LSQ procedure in TSP when estimating the seemingly unrelated regression problem uses the multivariate Gauss-Newton method to estimate the parameters in the system. This procedure generates parameter estimates, standard errors, and probability values; also, a goodness of fit measure for each equation (R^2), the Durbin Watson statistic for each equation, and the log likelihood function value for the system. (Hall and Cummins, 1998)

Since the DFAM is a singular system due to the adding up constraint, an equation must be deleted from the system when using the LSQ procedure. The equation deleted is the ROW equation, which is the least important equation to the system. However, parameter estimates for this equation are recovered by re-estimating the system with another equation deleted and this one replaced. This is possible because parameter estimates are invariant to the equation deleted when using maximum likelihood estimation (Barten, 1969).

The system goodness of fit measure used is the measure presented by Bewley (1986):

$$W^* = \pi_1^2 + \pi_2^2 + \dots + \pi_{n-1}^2 \quad (2)$$

where W^* is the Wald statistic that forces all the coefficients in the system to zero. T is the number of observations, n is the number of equations in the full system, and k is the number of

regressors in each equation. The Wald statistic for the hypothesis test that forces all the coefficients to zero is generated using the ANALYZ procedure in TSP.

The test for AR(1) in the DFAM model is accomplished using the likelihood ratio (LR) test where the DFAM with AR(1) imposed is the unrestricted model and the DFAM without AR(1) is the restricted model. In this study, the estimate of the autocorrelation parameter ρ will be obtained using full maximum likelihood estimation where ρ will be common across equations. This procedure is found in Berndt and Savin (1975), Green et al. (1978) and Beach and MacKinnon (1979). The test for autocorrelation will be performed using the likelihood ratio test. In this procedure the DFAM model will be estimated with and without AR(1) disturbances. The likelihood ratio test will then be used to test the hypothesis $\rho = 0$, where the DFAM with non-autocorrelated disturbances will be the restricted model. If autocorrelation can not be rejected, then the autocorrelated DFAM will be used to test for economic properties and forecasting.

The DFAM allows for homogeneity, symmetry, and negative semi-definiteness to be tested, imposed, or checked. The homogeneity property is satisfied when $\sum_j \pi_{ij} = 0$, which implies that $\pi_{in} = -\pi_{i1} - \pi_{i2} - \dots - \pi_{i(n-1)}$. Imposing this restriction on equation (1) yields (Theil, 1971)

$$\bar{f}_{it} D_{it} = \theta_i D X_t + \sum_{j=1}^{n-1} \pi_{ij} (D w_{jt} - D w_{nt}) + \varepsilon_{it} . \quad (3)$$

Equation (3) will be estimated using the LSQ procedure in TSP. The resulting log likelihood value will be obtained from the estimation procedure and used in a LR test to determine if the homogeneity constraint is valid. For this test, the homogeneity-constrained model is the restricted model that will be compared to the unconstrained system.

The symmetry constrained ML estimator can be obtained using the LSQ procedure in TSP as well. This is accomplished by first imposing homogeneity and then restricting the symmetric parameters equal. For example, the i th price coefficient in the j th equation will be restricted to equal the j th price coefficient in the i th equation. Once these restrictions are imposed, estimates are obtained using the LSQ procedure. The log likelihood value of this estimation will be used to verify the symmetry property, where the symmetry constrained system is the restricted model and the homogeneity-constrained system is the unrestricted model.

The property of negative semi-definiteness is verified by inspection of the eigenvalues of the price coefficient matrix. This property is verified when all of the eigenvalues are less than or equal to zero. If any values are questionable, judgement will be made based on the standard errors of the price coefficient estimates.

Mean –based elasticities will be calculated using the constrained parameters resulting from the estimation procedure. These elasticities are as follows.

$$\varepsilon_{xw} = \frac{Dx_i}{Dw_j} = \frac{\pi_{ij}}{f_i}. \quad (4a)$$

Equation (4a) is the conditional own and cross price elasticity. This will be evaluated at the mean factor share. Equation (4a) is the percentage change in the quantity demanded of an imported dairy product from the i th source country resulting from a 1 percent change in the price of that same product from source country j .

$$\varepsilon_{xX} = \frac{Dx_i}{DX} = \frac{\theta_i}{f_i}. \quad (4b)$$

Equation (4b) is the Divisa index elasticity, which reflects the effects of a change in the Divisa index on imports from the various source countries. Given that this index is proportional to total imports, this elasticity reflects the effects of total import changes on source-specific imports.

Objectives of this study are to project future derived demand for dairy products in the selected international markets, and to simulate the effects of trade liberalization. Given the left-hand side of equation (1), quantity forecasts are not easily obtained. There are two methods for obtaining quantity forecasts with the DFAM. The first method is a model-based approach, which uses the estimated model as a mean of forecasting future quantities. The model-based forecasting equation for the DFAM is

$$x_{it} = \exp \left[\frac{\theta_i DX_t + \sum_{j=1}^n \pi_{ij} (\log w_{it} - \log w_{it-1})}{\frac{\frac{w_{it} x_{it}}{\sum_{i=1}^n w_{it} x_{it}} + \frac{w_{it-1} x_{it-1}}{\sum_{i=1}^n w_{it-1} x_{it-1}}}{2}} + \log x_{it-1} \right]. \quad (5)$$

Use of equation (5) requires that the Divisa index and prices are exogenous, where the only unknowns are the individual quantities. Given prices, the Divisa index, and all lag values, equation (5) results in a system of i equations with i unknowns which can be solved for the x 's using the SOLVE procedure in TSP. This procedure uses a Gauss-Seidel algorithm.

The second method is the elasticity based approach, similar to the approach used by Kastens and Brester (1996). The elasticity-based forecasting equation for the DFAM is

$$x_{i,t} = \left(\sum_{j=1}^n \varepsilon_{ij} \left[\frac{w_{jt} - w_{jt-1}}{w_{jt-1}} \right] + \varepsilon_i [DX_t] \right) x_{it-1} + x_{it-1} \quad (6)$$

where ε_{ij} and ε_i are the price and Divisa elasticity respectively evaluated at the mean. Both procedures will use results from the estimation procedure where the economic properties of homogeneity and symmetry are imposed.

The first step in the forecasting and simulation procedure is to determine which of the two approaches is most accurate in terms of forecasting. To determine which method is best, each of the DFAM systems are estimated using all except the last 3 to 5 years of the data sets. Using both model-based and elasticity-based forecasting methods to forecast the remaining years, the precision of each of these methods determined which of the two procedures to use in forecasting and simulating future periods.

Future imported quantities of imported dairy products resulting from trade liberalization are simulated until the year 2003, which is the first half of the new World Trade Organization (WTO) implementation period. The policy that will be investigated is the further reduction in export subsidies permitted to the EU. Although the U.S. subsidizes dairy exports, subsidized exports to Asian countries overall have been negligible.

In order to assess the effects of subsidy reductions on the quantity of imported cheese demanded by Hong Kong, we must first know how subsidy reductions affect the price that an individual exporting country charges. Since export subsidies are a policy exclusive to the exporting country, the importing country only realizes a lower price for the products exported under subsidy. Since we are assuming that imported products are differentiated by country of origin, we can view the EU-cheese market as a separate market when analyzing the effects of export subsidy changes. When subsidies are reduced, this results in a fall in the total exported, thereby increasing the world price of EU-cheese. The increase in the world price is the only change realized in the Japanese market for EU-cheese. This indicates that a reduction in export subsidies can be simulated in the DFAM by increasing the price of the subsidized commodity. However, what is still needed is the effect of a subsidy reduction on prices. Gardner (1987)

shows that the elasticity of demand price with respect to a 1 percent change in a producer subsidy payment is

$$\frac{\% \Delta P}{\% \Delta V} = \frac{-1}{1 - \eta/\varepsilon} \quad (7)$$

where P is the demand price, V is the subsidy payment, η and ε are the own price demand and supply elasticity respectively. Applying equation (7) to export subsidies, it becomes the percentage change in the world price of the subsidized product resulting from a 1 percent change in export subsidy payments. The resulting change in price will then be used in either of the two forecasting procedures to assess the changes in import demand.

The Commodity Trade Statistics section of the United Nations provided the data used in this study. Imported quantities are in metric tons and values are in \$1000US. Source countries are the U.S., Oceania, and the EU. The time period for the data set was from 1962 to 1998. The value of imports was on a cost, insurance, and freight (CIF) basis, which include the cost of the product, the insurance paid, and the transportation cost. Commodity prices were calculated by dividing the value of the commodity imported by the quantity, which results in a per-unit cost per kilogram measure. The rest of the world quantities and values were calculated by subtracting the total quantity and value imported from the U.S., Oceania, and the EU.

Empirical Results

The first step in the estimation procedure was to test for the presence of autocorrelation in each of the systems. Since estimation of the DFAM requires that we take the first difference of the log of the variables, this is often a correction for autocorrelation; however, autocorrelation may still exist. A Likelihood ratio (LR) test was used to test for the presence of AR(1) in the estimated system. This test required that the DFAM be estimated with and without AR(1)

Table 1-1 Likelihood ratio test results for economic constraints

Country/Product	Model	Log-likelihood Value	LR*	$P[\chi^2_{(j)} \leq LR^*] = .95$
Hong Kong Cheese	Unrestricted	213.825		
	Homogeneity	212.172	3.306	7.81(3) ^a
	Symmetry	210.814	2.715	7.81(3)

^a The number of restrictions are in parenthesis.

disturbances where the autocorrelated version of the DFAM was the unrestricted model and the DFAM without autocorrelation was the restricted model. Results indicate that the hypothesis of no autocorrelation was rejected by at least the .05 significance level. Therefore AR(1) must be accounted for.

In addition to autocorrelation, LR tests were also used to test if the data satisfied the economic properties, homogeneity and symmetry. The results of these tests are summarized in Table 1-1. LR tests indicate that the property of homogeneity and symmetry could not be rejected.

The property of negative semidefiniteness was verified by inspection of the eigen values of the price coefficient matrix. This property is validated when all of the eigen values are less than or equal to zero. All eigen values were non-positive. Eigen values that had zeros up to the fifth decimal place were considered to be zero.

Since homogeneity and symmetry could not be rejected results have homogeneity and symmetry imposed. Results also have AR(1) imposed as well. Since symmetry is imposed, the lower triangular portion of the price coefficient matrix is exactly equal to upper triangular portion, and is therefore left blank. The marginal share (θ_i) coefficients for each equation in the

Table 1-2 DFAM parameter estimates for Hong Kong imports of cheese

Exporting Country	Price Coefficients, π_{ij}				Marginal Factor Shares, θ_i
	U.S.	Oceania ^a	EU	ROW ^b	
U.S.	-.1040 (.0131) ^{c***}	.0217 (.0265)	.0512 (.0263)*	.0311 (.0185)*	.0864 (.0251) ^{***}
Oceania		-.1446 (.0874)*	.1844 (.0774)**	-.0615 (.0485)	.4823 (.0645) ^{***}
EU			-.3192 (.1026)**	.0836 (.0579)	.3597 (.0647) ^{***}
ROW				-.0533 (.0536)	.0716 (.0390)*
System R ² = .91					

^a Australia and New Zealand aggregation.

^b ROW= rest of the world.

^c Asymptotic standard errors are in parentheses.

*** Significant level = .01

** Significant level = .05

* Significant level = .10

system are all significant at any reasonable significance level. The marginal shares are also all positive, indicating that as total imports grow, imports from the individual exporting countries grow as well. All own-price coefficients are negative, which is to be expected, and with the exception of the ROW, the own-price coefficients are all significant by at least the .10 significance level. With the exception of the Oceania/ROW cross-price coefficient, all cross-price coefficients are positive, indicating that these goods are for the most part substitutes. The negative cross-price coefficient for Oceania and the ROW indicate a possible complementary relationship between the imports from these two sources. This may be due to the fact that the more generic brands of cheese are from these sources and these types of cheeses may be purchased together. These goods may also be independent given that the parameter estimate is

Table 1-3 Hong Kong Divisia and price elasticities of the derived demand for imported cheese

Exporting Country	Divisia Import	Conditional Own-Price	Elasticities			
			Conditional Cross-Price			
			U.S.	Oceania ^a	EU	ROW ^b
U.S.	<i>1.284</i> ^c (.373) ^c	<i>-1.546</i> (.195)		.323 (.393)	.761 (.391)	.462 (.274)
Oceania	<i>1.013</i> (.136)	<i>-.304</i> (.183)	.046 (.056)		.387 (.163)	-.129 (.102)
EU	<i>1.196</i> (.215)	<i>-1.061</i> (.339)	.170 (.087)	.613 (.257)		.278 (.192)
ROW	<i>.459</i> (.250)	<i>-.342</i> (.344)	.200 (.118)	-.394 (.311)	.537 (.372)	

^a Australia and New Zealand aggregation.

^b ROW = rest of the world.

^c *Italics* indicate that the elasticity was significant by at least .10.

^c Asymptotic standard errors are in parentheses.

not statistically different from zero. Of the cross-price coefficients, three were significant. These are the U.S./EU, U.S./ROW and the Oceania/EU cross-price coefficients. All indicate that goods from these sources are substitutes (Table 1-2).

Table 1-3 presents the Divisia import and conditional own and cross-price elasticities for Hong Kong's derived demand for imported cheese. The Divisia import elasticities for the U.S., Oceania, EU, and the ROW are 1.284, 1.013, 1.196, and .459 respectively. Of these elasticities, all are significant by at least the .10 significance level. The Divisia import elasticity is somewhat similar to a total import elasticity, which would indicate the percentage change in imports from the exporting countries given a percentage change in total imports. Given that the Divisia index is proportional to a percentage change in the total quantity imported, the Divisia elasticity indicates a similar relationship as the total import elasticity. Of all the Divisia elasticities, the

U.S. elasticity is the largest. This indicates that as total imports of cheese into Hong Kong increase such that the Divisia index increases, U.S. cheese imports into Hong Kong should increase by a larger percent when compared to the increase in imports from other exporting sources. However, with the exception of the ROW, these elasticities are not significantly different from 1. This indicates that as total imports of cheese increase in Hong Kong, imports from the primary sources should increase by the same percent as total imports.

The own-price elasticities of Hong Kong's derived demand for imported cheese from the U.S., Oceania, EU and the ROW are -1.546 , $-.304$, -1.061 and $-.342$ respectively. Except for the ROW all own-price elasticities are significant at the .10 significance level. Elasticities indicate that the derived demand for U.S. and EU cheese in Hong Kong is highly elastic, with the demand for U.S. cheese being the most elastic of all the exporting sources. The derived demand for Oceania cheese is inelastic, indicating that cheese from Oceania imported into Hong Kong is less responsive to price changes than imports from other sources. The inelastic demand for Oceania cheese may be due to their prices being less than all other prices from competing sources.

Cross-price elasticities indicate a substitutional relationship between exporting sources for cheese imports into Hong Kong. The cross-price elasticity that stands out is the U.S.-EU elasticity, which says that if the price of EU cheese increase by 1 percent, the quantity demanded for U.S. cheese will increase by .761 percent. The Oceania-EU cross-price elasticity indicates that imports from Oceania will increase by .387 percent. This suggests that the U.S. stand to benefit more than Oceania percentage wise when EU dairy export subsidy reductions lead to increases in the EU cheese price (Table 1-3).

Hong Kong's derived demand system for imported cheese was re-estimated using all of the available years except the last five (1994-1998). Once new estimates were obtained, model-

Table 1-4 Percentage differences in the actual quantities and forecasts for Hong Kong cheese imports: 1994-1998

Model-Based Forecasts					
Year	U.S.	Oceania ^a	EU	ROW ^b	Overall Average
<i>Percent</i>					
1994	45.8	6.3	4.5	12.0	
1995	58.1	11.0	1.2	25.6	
1996	29.1	16.0	16.4	25.7	
1997	23.9	16.8	7.4	115.5	
1998	53.1	16.2	12.0	124.3	
Average	42.0	13.2	8.3	60.6	31.0
Elasticity-Based Forecasts					
1994	23.7	1.4	5.8	21.2	
1995	11.6	1.6	2.1	10.0	
1996	18.8	6.4	18.9	16.9	
1997	40.7	3.1	9.4	27.8	
1998	62.7	0.6	18.7	31.9	
Average	31.5	2.6	11.0	21.5	16.7

^a Australia and New Zealand aggregation.

^b ROW = rest of the world.

based and elasticity based forecasting equations were used to forecast imported quantities for the remaining years. This was done to determine which of the two equations forecasted with the most precision. Precision of forecasts was determined by the absolute percentage difference in the forecasted and actual quantities. Table 1-4 presents the absolute percentage difference in the actual and forecasted values. Results show that the forecasting precision of the elasticity-based approach was a 14 percent improvement over model-based forecasts on average. For each

country, forecasts improved by as much as 39 percent when using elasticities instead of the model to forecasts.

Out of commitment to the Uruguay Round (UR) General Agreement on Tariffs and Trade (GATT), the EU has agreed to reduce export subsidy expenditures by 36 percent during the period 1995 to 2000. The question thus arises, how will import quantities change given the continuation of this policy or that new trade policy is more aggressive.

Equation (7) was used to assess the percentage change in demand price resulting from a percentage change in a producer subsidy payment. Zhou et al. (1998) indicates that the own-price supply elasticity for the EU is .65 for all milk produced and the own-price demand elasticity for cheese and dry milk is -0.40. Using these elasticities in equation (7), the elasticity of the cheese demand price with respect to a subsidy payment is -0.619. A 36 percent reduction over a six-year period is a 6 percent per year reduction on average. Using -0.619, a 6 percent subsidy reduction results in a 3.7 percent increase in the demand price per year. A 72 percent subsidy reduction over a six-year period results in a 7.43 percent per year increase in the demand price. These percentages are used to simulate the effects of EU subsidy reductions at the current rate and twice the current rate. Since the UR GATT implementation period ends the year 2000, the 72 percent reduction is applied to the period 2001 to 2003.

Table 1-5 Hong Kong cheese imports given a 36 and 72 percent EU export subsidy reduction: 1999-2003

Year	U.S.	Oceania ^a	EU	ROW ^b
36% Subsidy Reduction: 1999-03				
<i>Metric tons</i>				
1999	760.91	5,293.04	1,356.34	130.55
2000	782.41	5,369.17	1,302.87	133.16
2001	804.52	5,446.39	1,251.51	135.81
2002	827.26	5,524.72	1,202.18	138.52
2003	850.64	5,604.17	1,154.79	141.28
36% Subsidy Reduction: 1999-00 72% Subsidy Reduction: 2001-03				
1999	760.91	5,293.04	1,356.34	130.55
2000	782.41	5,369.17	1,302.87	133.16
2001	826.63	5,523.61	1,200.15	138.47
2002	873.35	5,682.48	1,105.53	143.99
2003	922.71	5,845.93	1,018.37	149.73

^a Australia and New Zealand aggregation.

^b ROW = rest of the world.

Table 1-5 presents the expected quantities of cheese imported into Hong Kong if the upcoming World Trade Organization (WTO) agreement continues subsidy reduction at the current rate or twice the rate of the UR GATT agreement. If reductions continue at the same pace, imports of U.S. cheese into Hong Kong for the period 1999 to 2003 are expected to increase from 761 to 850 metrics. Imports from Oceania are expected to increase from 5,293 to 5,604 metric tons for an overall increase of 311 metric tons. Imports from the EU are expected to decrease by 201 metric tons. Imports from all other sources are expected to increase by 11 metric tons. If subsidy reductions for the WTO agreement are twice the UR GATT rate, imports

from the U.S. for the same period is expected to increase from 761 to 923 metric tons, an increase of 162 metric tons. Imports from Oceania are expected to increase to 5,846 metric tons, an increase of 553 metric tons. Imports from the EU will be down by over 300 metric tons. Imports from all other sources are expected to increase by 19 metric tons.

Overall, simulation results suggest that Oceania will be the primary beneficiary from EU subsidy reductions for both rates of reduction. This is in terms of quantity only. In terms of percentages, Hong Kong imports of cheese from the U.S. is expected to increase by 12 percent if policy continues and 21 percent if reductions in subsidies are twice the current rate. Oceania imports will increase by 6 and 10 percent respectively.

Conclusions

This study is an attempt to assess the competitiveness of U.S. cheese imported into Hong Kong. Given the total elimination of dairy price supports by January 1, 2000, and given the 21 percent quantity and 36 percent expenditure reduction in subsidized dairy exports, U.S. producers of dairy products have gained interest in obtaining a greater market share of international markets. Given that the U.S. has had a relatively small market share of world dairy trade, the degree to which U.S. products compete in international markets is unknown. This study attempts to give the U.S. dairy industry a snapshot of how cheese products have been competing in Hong Kong on average from past to present.

Simulation results send a clear message to the U.S. dairy industry. Overall, imports of US cheese into Hong Kong are expected to increase as a result of EU export subsidy reductions; however, the larger quantity increase is expected to come from Oceania imports.

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