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The derived demand for imported cheese in Hong Kong

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Abstract

The objective of this paper was to provide the U.S. dairy industry with empirical estimates of Hong Kong's derived demand for imported cheese differentiated by source country of production. These estimates were used to simulate the effects of European Union (EU) subsidy reductions on the U.S. share of Hong Kong cheese imports. Simulation results suggested that Oceania was the primary beneficiary from EU subsidy reductions. Hong Kong cheese imports from the U.S. were expected to increase by 12% if subsidy reductions continue at the same pace as the 1994 GATT agreement and 21% if reductions were twice the pace.

1. Introduction

The Federal Agriculture Improvement and Reform Act of 1996 (FAIR Act) legislated a phase out of dairy price supports by January 1, 2000. This phase-out was recently extended through 2001. As a result of the General Agreements on Tariffs and Trade (GATT), subsidized U.S. dairy exports, as well as exports from other countries, were reduced 36% by the year 2000 with more reductions expected as trade negotiations continue. These changes in policy and the reduction of the number of dairy farms have made gaining a larger share of world dairy exports more important to U.S. producers/processors. Evidence of this concern was the willingness of the industry to create and fund the U.S. Dairy Export Council (USDEC) in 1995. USDEC has nine offices located in nine countries around the world.

Given the increased emphasis on the export market, the dairy industry was in need of demand information by country and by individual dairy product. Import demand work for

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various countries (Dobson, 1992, 1995; Zhu & Novakovic, 1996) has been minimal and qualitative in nature. However, the dairy industry was in need of a quantitative analysis of import demand for various countries in order to provide the U.S. dairy industry with the demand characteristics of their chosen markets. The U.S. dairy industry needed information upon which to build export markets and they needed help now in lieu of assistance in the future when the export markets were developed.

Of all international markets investigated by USDEC, Hong Kong had been identified as having significant growth potential in demand for U.S. dairy products. This identification was based on (1) milk and dairy product consumption per-capita in Hong Kong tended to be higher than in other Asian countries (USDEC, 1996), (2) per-capita milk consumption had grown by nearly 10% annually since 1990 (FAO Statistics, 1999), (3) Hong Kong had experienced vast economic growth the last two decades (Central Intelligence Agency, 1999), (4) increased trade with Hong Kong could further expose U.S. dairy products to the emerging dairy markets of China since Hong Kong was a major re-exporter to China, and (5) the European Union (EU) had supplied Hong Kong with over 70% of its dairy imports which were expected to decline as the removal of export subsidies progressed. Additionally, due to limited resources, Hong Kong is nearly 100% dependent on dairy imports to satisfy demand. Regarding trade restrictions, Hong Kong pursued a policy of non-interference in custom practices where dairy imports were subject to import licensing for sanitary conditions and record keeping purposes only (USDEC, 1996; U.S. State Department, 1997; WTO, 1998). USDEC had an office in Hong Kong, which demonstrated their belief in Hong Kong's demand potential.

Since 1991, growth in U.S. cheese exports had been strong. For the period 1991–1997, the quantity of cheese exported from the U.S. grew by 20% per year. Dobson (1995) notes that there is great potential in U.S. cheese exports due to the fact that it is highly differentiable and may command a premium price in international markets. Zhu and Novakovic (1996) also note that in Asian markets, U.S. cheese is considered high quality when compared to cheese from Australia and New Zealand.

For the last 40 years, Hong Kong cheese imports grew by over 9% annually. However, during this time period, less than 10% was imported from the U.S. The two regions that dominated this market during this period were Oceania (48%) and the EU (30%) (FAO Statistics, 1999). Given that EU cheese exports to Hong Kong were subsidized and the U.S. subsidized no dairy exports to Hong Kong, could the U.S. obtain the EU lost sales when dairy export subsidies were removed by EU, particularly in the cheese market?

The objective of this paper was to provide the U.S. dairy industry with empirically estimated elasticities of Hong Kong's derived demand for imported cheese differentiated by country of production. These estimates were used to assess the relative competitiveness of cheese imported from the U.S. with cheese imported from other countries. The elasticities also were used to simulate the effects of EU subsidy reductions on the U.S. share of Hong Kong cheese imports. Past studies that assessed the demand for imports differentiated by source country of production used a utility or consumer approach to obtain import demand equations. However, given that imported dairy products were purchased by firms, and that a significant amount of transformation and/or value added took place after goods reached the importing country, this article estimated demand from a production approach where imports were inputs into production processes.

Specific objectives were (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 imported cheese in Hong Kong.

2. Methodology

The econometric model used to estimate the derived demand for imported cheese into Hong Kong was the differential factor allocation model (DFAM) derived from the differential approach to the theory of the firm (Laitinen, 1980). This model is given by

$$\bar{f}_{it} Dx_{it} = \theta_i DX_t + \sum_{j=1}^{n} \pi_{ij} Dw_{jt} + \varepsilon_{it} \tag{1}$$

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

A key feature of the DFAM was that production theory was imposed on the system to determine if the data was consistent with theory. Homogeneity and symmetry were imposed and tested, and negative semi-definiteness was checked by inspection of the eigenvalues of the price coefficient matrix. The homogeneity property in the DFAM model was satisfied when $\sum_j \pi_{ij} = 0$. Symmetry was satisfied when $\pi_{ij} = \pi_{ji}$ (Washington, 2000).

When applied to the estimation of the derived demand for cheese imports into Hong Kong, Eq. (1) was the ith derived demand equation for imported cheese into Hong Kong from exporting country i, where $i \in$ (U.S., Oceania, EU, ROW). ROW was the rest of the world, which in this instance was an aggregation of all imports of cheese into Hong Kong not imported from the U.S., Oceania, or the EU. Oceania was an aggregation of Australia and New Zealand. The Divisia input index was an index of total cheese imports into Hong Kong. The f_i was the total cost of cheese from source country i divided by the total cost of all cheese imported into Hong Kong. The w_i's were the prices for imported cheese charged by the exporting countries. The x_i was the quantity of cheese imported into Hong Kong from the ith exporting source.

Estimation of the system of equations represented by Eq. (1) were accomplished by using the LSQ procedure in the econometric program package, Time Series Processor (TSP), version 4.4. This procedure used the multivariate Gauss–Newton method to estimate the parameters in the system. The output from LSQ included parameter estimates, standard errors, probability values, 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 & Cummins, 1998).

The system goodness of fit measure used was (Bewley, 1986)

$$R_W^2 = 1 - \frac{1}{1 + W^*/(T-k)(n-1)} \tag{2}$$

where W^* is the Wald statistic that forced all the coefficients in the system to zero, T the number of observations, n the number of equations in the full system, and k is the number of regressors in each equation.The test for AR(1) in the DFAM model was accomplished using the likelihood ratio (LR) test where the DFAM with AR(1) imposed was the unrestricted model and the DFAM without AR(1) was the restricted model. In this study, the estimate of the autocorrelation parameter ρ was obtained using full maximum likelihood estimation where ρ was common across equations. This procedure was found in Berndt and Savin (1975), Green, Hassan, and Johnson (1978) and Beach and MacKinnon (1979).

The DFAM allows for homogeneity, symmetry, and negative semi-definiteness to be tested, imposed, or checked. The homogeneity property was satisfied when $\sum_j \pi_{ij} = 0$, which implied that $\pi_{in} = -\pi_{i1} - \pi_{i2} - \cdots - \pi_{in-1}$. Imposing this restriction on Eq. (1) yielded (Theil, 1971)

$$\bar{f}_{it} D_{it} = \theta_i DX_t + \sum_{j=1}^{n-1} \pi_{ij}(Dw_{jt} - Dw_{nt}) + \varepsilon_{it}. \tag{3}$$

Eq. (3) was estimated using the LSQ procedure in TSP. The resulting log likelihood value was obtained from the estimation procedure and used in a LR test to determine if the homogeneity constraint was valid. For this test, the homogeneity-constrained model was the restricted model that was compared to the unconstrained system. The symmetry constrained ML estimator was obtained using the LSQ procedure in TSP as well. The property of negative semi-definiteness was verified by inspection of the eigenvalues of the price coefficient matrix.

Mean-based elasticities were calculated using the constrained parameters resulting from the estimation procedure. These elasticities were

$$\varepsilon_{xw} = \frac{Dx_i}{Dw_j} = \frac{\pi_{ij}}{f_i} \tag{4}$$

and

$$\varepsilon_{xX} = \frac{Dx_i}{DX} = \frac{\theta_i}{f_i}. \tag{5}$$

Eq. (4) is the conditional own- and cross-price elasticity. This is evaluated at the mean factor share. Eq. (4) is the percentage change in the quantity demanded of an imported dairy product from the ith source country resulting from a 1% change in the price of that same product from source country j. Eq. (5) is the Divisia index elasticity, which reflected the effects of a change in the Divisia index on imports from the various source countries. Given that this index was proportional to total imports, this elasticity reflected the effects of total import changes on source-specific imports.

Future imported quantities of imported dairy products resulting from reductions in EU export subsidies were simulated until year 2003, which was the first half of the new World Trade Organization's (WTO) implementation period. In order to assess the effects of subsidy reductions on the quantity of imported cheese demanded by Hong Kong, a person must know how subsidy reductions affected the price that an individual exporting country charged. Since export subsidies were a policy exclusive to the exporting country, the importing country only realized a lower price for the products exported under subsidy. Given that imported products were differentiated by country of origin, the EU cheese market was viewed as a separate market when analyzing the effects of export subsidy changes. When subsidies were reduced, this resulted in a fall in the total exported, thereby increasing the import price of EU cheese. The increase in the import price was the only change realized in the Hong Kong market for EU cheese. This indicated that a reduction in export subsidies could be simulated in the DFAM by increasing the price of the subsidized commodity. However, the effect of a subsidy reduction on prices was still needed. Gardner (1987) shows that the elasticity of demand price with respect to a 1% change in a producer subsidy payment is

$$\frac{\%\Delta P}{\%\Delta V} = \frac{-1}{1 - \eta/\varepsilon} \tag{6}$$

where P is the demand price; V the subsidy payment; η and ε are the own-price demand and supply elasticities, respectively. Applying Eq. (6) to export subsidies, it became the percentage change in the import price of the subsidized product resulting from a 1% change in export subsidy payments. The change in price was 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 article. Imported quantities were in metric tons and values were in \$1000. Source countries were the U.S., Oceania, and the EU. The time period for the dataset was from 1962 to 1998. The value of imports was on a cost, insurance, and freight (CIF) basis, which included 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 resulted 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.

3. Empirical results

Results indicated that the hypothesis of no autocorrelation was rejected at the 0.05 significance level (Table 1). Therefore, autocorrelation must be accounted for and the order of this process is AR(1). In addition to autocorrelation, LR tests also were used to test if the data satisfied the economic properties, homogeneity and symmetry. The results of these tests are in Table 1. LR tests indicate that the property of homogeneity and symmetry could not be rejected. The property of negative semi-definiteness was verified by inspection of the eigenvalues of the price coefficient matrix. This property is validated when all of the

Table 1
Likelihood ratio test results for AR(1) and economic constraints

Model	Log-likelihood value	LR	$p[\chi^2_{(j)} \leq \text{LR}] = 0.95$
No-AR(1)	211.942		
AR(1)	213.946	4.008	3.84(1)[a]
Unrestricted[b]	213.946		
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.
[b] The unrestricted model and the AR(1) model are the same model since No-AR(1) was rejected.

eigenvalues are less than or equal to zero. All eigenvalues were non-positive. Eigenvalues 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 was imposed, the lower triangular portion of the price coefficient matrix was exactly equal to upper triangular portion, and was left blank. The marginal share (θ_i) coefficients for each equation in the system were all significant at any reasonable significance level. The marginal shares also were all positive, indicating that as total imports grew, imports from the individual exporting countries grew as well. All own-price coefficients were negative, which was to be expected, and with the exception of the ROW, the own-price coefficients were all significant by at least the 0.10 significance level. With the exception of the Oceania/ROW cross-price coefficient, all cross-price coefficients were positive, indicating that these goods were substitutes. The negative cross-price coefficient for Oceania and the ROW indicated a possible complementary relationship between the imports from these two sources; however, these goods were independent given that the parameter estimate was not statistically different from zero. Of the cross-price coefficients, three were significant. These were the U.S./EU, U.S./ROW and the Oceania/EU cross-price coefficients. All indicated that goods from these sources are substitutes (Table 2).

Table 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 were 1.284, 1.013, 1.196, and 0.459, respectively. Of these elasticities, all were significant by at least the 0.10 significance level. The Divisia import elasticity was similar to a total import elasticity, which indicated the percentage change in imports from the exporting countries given a percentage change in total imports. Given that the Divisia index was proportional to a percentage change in the total quantity imported, the Divisia elasticity indicated a similar relationship as the total import elasticity. Of all the Divisia elasticities, the U.S. elasticity was the largest. This indicated that as total imports of cheese into Hong Kong increased such that the Divisia index increases, U.S. cheese imports into Hong Kong increased by a larger percent when compared to the increase in imports from other exporting sources.

The own-price elasticities of Hong Kong's derived demand for imported cheese from the U.S., Oceania, EU and the ROW were −1.546, −0.304, −1.061 and −0.342, respectively. Except for the ROW, all own-price elasticities were significant at the 0.10 significance level.

Table 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.	−0.1040 (0.0131)[c,***]	0.0217 (0.0265)	0.0512 (0.0263)[*]	0.0311 (0.0185)[*]	0.0864 (0.0251)[***]
Oceania		−0.1446 (0.0874)[*]	0.1844 (0.0774)[**]	−0.0615 (0.0485)	0.4823 (0.0645)[***]
EU			−0.3192 (0.1026)[**]	0.0836 (0.0579)	0.3597 (0.0647)[***]
ROW				−0.0533 (0.0536)	0.0716 (0.0390)[*]
Equation R^2	0.63	0.47	0.43	0.20	
System $R^2 = 0.91$					

[a] Australia and New Zealand aggregation.
[b] ROW: rest of the world.
[c] Asymptotic standard errors are in parentheses.
[*] Significant level = 0.10.
[**] Significant level = 0.05.
[***] Significant level = 0.01.

Elasticities indicated that the derived demand for U.S. and EU cheese in Hong Kong was highly elastic, with the demand for U.S. cheese being the most elastic of all the exporting sources. The derived demand for Oceania cheese was inelastic, indicating that cheese from Oceania imported into Hong Kong was less responsive to price changes than imports from other sources.

Cross-price elasticities indicated a substitutional relationship between exporting sources for cheese imports into Hong Kong. The cross-price elasticity that stands out was the U.S./EU elasticity, which says that if the price of EU cheese increased by 1%, the quantity demanded for U.S. cheese increased by 0.761%. The Oceania/EU cross-price elasticity indicated that imports from Oceania increased by 0.387%. This suggested that the U.S. stands to benefit more than Oceania (percentage-wise) when EU dairy export subsidy reductions lead to increases in the EU cheese price (Table 3).[2]

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

Exporting country	Elasticities					
	Divisia import	Conditional own-price	Conditional cross-price			
			U.S.	Oceania[a]	EU	ROW[b]
U.S.	*1.284*[c] (0.373)[d]	*−1.546* (0.195)		0.323 (0.393)	*0.761* (0.391)	*0.462* (0.274)
Oceania	*1.013* (0.136)	*−0.304* (0.183)	0.046 (0.056)		*0.387* (0.163)	−0.129 (0.102)
EU	*1.196* (0.215)	*−1.061* (0.339)	*0.170* (0.087)	*0.613* (0.257)		0.278 (0.192)
ROW	*0.459* (0.250)	−0.342 (0.344)	*0.200* (0.118)	−0.394 (0.311)	0.537 (0.372)	

[a] Australia and New Zealand aggregation.
[b] ROW: rest of the world.
[c] Italics indicate that the elasticity was significant by at least 0.10.
[d] Asymptotic standard errors are in parentheses which were obtained using the Delta Method in TSP.

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% during the period 1995–2000. The question, thus arises, how would import quantities change given the continuation of this policy or that new trade policy was more aggressive?

Eq. (6) was used to assess the percentage change in demand price resulting from a percentage change in a producer subsidy payment. Zhu et al. (1998) indicates that the supply elasticity for the EU is 0.65 for all milk produced and the own-price demand elasticity for cheese −0.40. Using these elasticities in Eq. (6), the elasticity of the cheese demand price with respect to a subsidy payment was −0.619. A 36% reduction over a 6-year period was a 6% per year reduction on average. Using −0.619, a 6% subsidy reduction resulted in a 3.7% increase in the demand price per year. A 72% subsidy reduction over a 6-year period resulted in a 7.43% per year increase in the demand price. These percentages were use to simulate the effects of EU subsidy reductions at the current rate and twice the current rate. Since the UR GATT implementation period ended in 2000, the 72% reduction was applied to the period 2001–2003.[3]

Table 4 presents the expected quantities of cheese imported into Hong Kong if the upcoming WTO agreement continued subsidy reduction at the current rate or twice the rate of the UR GATT agreement. If reductions continued at the same pace, imports of U.S. cheese into Hong Kong for the period 1999–2003 were expected to increase from 761 to 851 metric tonnes. Imports from Oceania were expected to increase from 5,293 to 5,604 metric tonnes for an overall increase of 311 metric tonnes. Imports from the EU were expected to decrease by 202 metric tonnes. Imports from all other sources were expected to increase by 11 metric tonnes. If subsidy reductions for the WTO agreement were twice the UR GATT rate, imports from the U.S. for the same period was expected to increase from 761 to 923 metric tonnes, an increase of 162 metric tonnes. Imports from Oceania were expected to increase to 5,846 metric tonnes, an increase of 553 metric tonnes. Imports from the EU were down by over 338 metric tonnes. Imports from all other sources were expected to increase by 19 metric tonnes.

Table 4
Hong Kong cheese imports given a 36% and 72% EU export subsidy reduction: 1999–2003

Year	U.S.	Oceania[a]	EU	ROW[b]
36% subsidy reduction: 1999–2003 (metric tonnes)				
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: 1999–2000, 72% subsidy reduction: 2001–2003				
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.

Overall, simulation results suggested that Oceania was the primary beneficiary from EU subsidy reductions for both rates of reduction. This was in terms of quantity. In terms of percentages, Hong Kong imports of cheese from the U.S. were expected to increase by approximately 12% if policy continued and approximately 21% if reductions in subsidies were twice the current rate. Oceania imports increased approximately 6% and 10%, respectively.

4. Summary, conclusions, and implications

This study assessed the competitiveness of U.S. cheese imported into Hong Kong. Given the possible elimination of U.S. dairy price supports and the 21% quantity and 36% 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 was unknown. This article gives the U.S. dairy industry a snapshot of how cheese products have been competing in Hong Kong from past to present.

When total cheese imports into Hong Kong change, U.S. cheese imports will change by a larger percent than that of other exporting sources. This means that as Hong Kong's per-capita income changes and/or population increases, the percentage change in the United States' exports into Hong Kong will change by more than any other country and the U.S. market share will increase.

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. This means that a change in the U.S. price will cause a larger change in the quantity consumed of U.S. cheese than that of any other country. If the U.S. reduces the price of its cheese, the total revenue for the U.S. will increase because the quantity sold will increase by a larger percentage than the decrease in price. Furthermore, when the U.S. lowers price, this reduces the quantity sold by the EU and the ROW. This will increase the market share of the U.S. Oceania is not likely to lower price because this will decrease its total revenue.

A competitive relationship between exporting sources for cheese imports into Hong Kong exists between the U.S. and the EU and the ROW. Thus, if the price of EU or ROW cheese were to change, the quantity of U.S. cheese demanded will also change in the same direction as the EU and ROW price. Therefore, as EU cheese price increases as the EU reduces its export subsidies, the U.S. will increase imports into Hong Kong. A competitive relationship does not exist between the U.S. and Oceania. This indicates that the U.S. is not competitive with Oceania, the largest importer into Hong Kong.

Finally, the U.S. will gain a larger market share in Hong Kong when the EU decreases its export subsidies which will increase the price of EU cheese imported into Hong Kong. In terms of percentages, Hong Kong imports of cheese from the U.S. will increase by approximately 12% if policy continued and approximately 21% if reductions in subsidies were twice the current rate. Oceania imports will increase approximately 6% and 10%, respectively. Thus, the U.S. will increase its market share.

In conclusion, the U.S. does not compete with Oceania, the largest cheese importer in Hong Kong. Oceania is not likely to reduce price because it will reduce total revenue and the quantity increase will be marginal. In fact, a price change by Oceania does not change the quantity of U.S. cheese demanded. The demand for U.S. cheese and the demand for Oceania cheese are independent. The U.S. competes with the EU and the ROW in the Hong Kong cheese market. The U.S. has incentive to decrease price in order to increase total revenue and increase market share. The implications are that the U.S. must compete on the basis of price. Second, the U.S. must determine the characteristics of the cheese that is sold by Oceania and compare them to the U.S. cheese. This will help the U.S. to become competitive with Oceania through product characteristics.

Notes

1. Davis (1997) used the differential production approach to estimate the import demand for broad aggregates. Washington used the differential production approach to estimate source-specific import demand.
2. Elasticity comparisons were not based on statistical tests, but on the relative magnitude of the elasticities.
3. Of the two forecasting methods considered, the elasticity-based method was selected because it had more precise "in sample" forecasts. Forecast selection results were summarized in Appendix A.

Appendix A

An objective of this study was to simulate the effects of the removal of export subsidies on Hong Kong cheese imports. Given the left-hand side of Eq. (1), quantity forecasts were not easily obtained. There were two methods for obtaining quantity forecasts with the DFAM. The first method was a model-based approach, which used the estimated model as a means of forecasting future quantities. The model-based forecasting equation for the DFAM was

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

Use of Eq. (A.1) required that the Divisia index and prices were exogenous, where the only unknowns were the individual quantities. Given prices, the Divisia index, and all lag values (Eq. (A.1)) 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 was the elasticity-based approached, similar to the approach used by Kastens and Brester (1996). The elasticity-based forecasting equation for the DFAM was

$$x_{i,t} = \left(\sum_{j=1}^{n}\varepsilon_{ij}\left[\frac{w_{jt} - w_{jt-1}}{w_{jt-1}}\right] + \varepsilon_i[DX_t]\right)x_{it-1} + x_{it-1} \tag{A.2}$$

Table A.1
Percentage differences in the actual quantities and forecasts for Hong Kong cheese imports: 1994–1998

Year	U.S. (%)	Oceania[a] (%)	EU (%)	ROW[b] (%)	Overall average
Model-based forecasts					
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.

where ε_{ij} and ε_i were the price and Divisia elasticities evaluated at the mean. Both procedures used results from the estimation procedure where the economic properties of homogeneity and symmetry were imposed.

The first step in the forecasting and simulation procedure was to determine which of the two approaches was most accurate in terms of forecasting. To determine which method was best, each of the DFAM systems were estimated using all except the last 5 years of the datasets. Using both model- 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.

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- 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 A.1 presented the absolute percentage difference in the actual and forecasted values. Results showed that the forecasting precision of the elasticity-based approach was a 14% improvement over model-based forecasts on average. For each country, forecasts improved by as much as 39% when using elasticities instead of the model to forecasts.

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