

## Elasticities of Chinese Demand for Imports of Melons from Vietnam and Myanmar

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### Abstract

Vietnam and Myanmar are major exporters of melons (*Citrullus lanatus*) to China. Among all fresh fruits, melons account for Myanmar's and Vietnam's largest export volume and values. Over 90% of Myanmar's melons are exported via border trade, primarily to China. Measuring the own- and cross-price elasticities of imported melons into China that come from Vietnam and Myanmar can help each exporter understand the market potential for their melons. The objective of the study was to estimate the own- and cross-price elasticities of imported melons into China differentiated by exporting country. The demand system of imported melons into China was estimated using a source-differentiated Linear Approximation of the Almost Ideal Demand System (LA-AIDS). The results suggest that imported melons are weakly separable from other imported fruits. While melons from Vietnam and Myanmar are substitutes for each other, the price of melons from the rest of the world (ROW) did not have a significant effect on China's imports of melons from Vietnam or Myanmar. The estimated coefficients from the seasonal dummy variables included in the demand equations show little seasonality in the market shares of Vietnam, Myanmar, and the ROW for melon imports to China.

### Keywords

LA-AIDS, Import demand, Price elasticities, Separability, Melon

### Introduction

China is not only a large producer but also a large consumer of agricultural products. Fruit imports account for 60% of the total value of China's horticultural imports (Rae *et al.*, 2006). Countries in the Association of Southeast Asian Nations (ASEAN) are the main exporters of tropical fruits to China because they have a comparative advantage due to their favorable climates for mass production of tropical fruits and their lower transportation costs due to shorter

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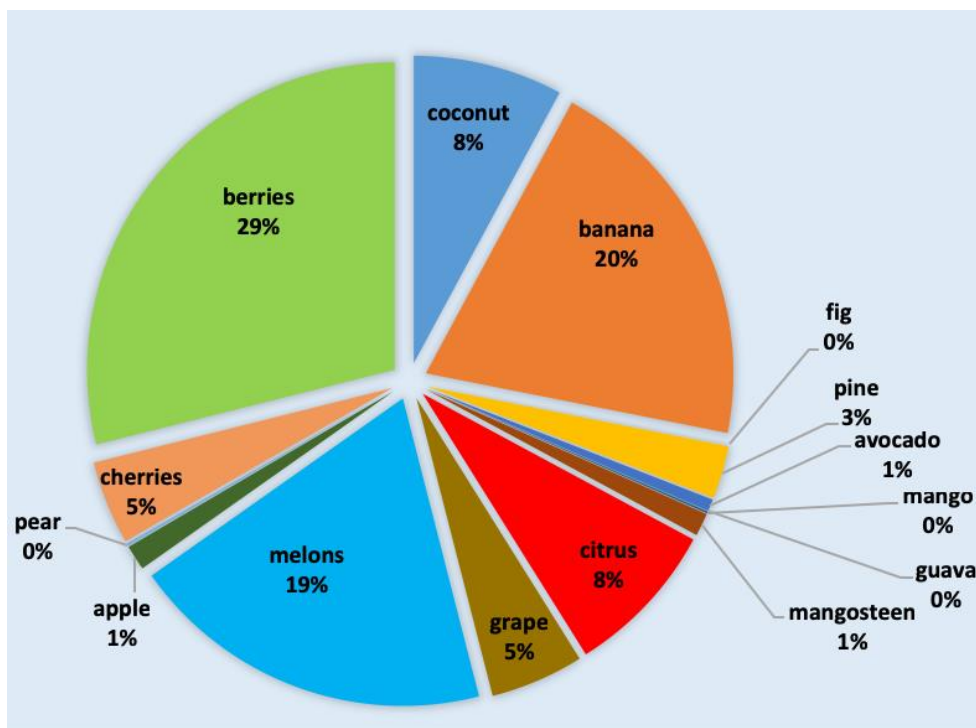
distances (ITC, 2011). Berries (*Rubus*, *Vaccinium*, *Ribe*) account for 29% of the total fruit imports (Figure 1), whereas melons (*Cucumis melo*) and bananas (*Musa*) are second and third with 20% and 19%, respectively.

According to the Food and Agriculture Organization of the United Nations (FAO) database, China leads the world production of melons with over 12 million tons, followed by Turkey and Iran which produce over 1.8 million and 1.4 million, respectively (FAO, 2017). Although China produces large amounts of melons, they export relatively little (Figure 2) because most of their production is consumed domestically. In China, the off-production season for melons is between November and April. It is during this period that most melons are imported from other countries to meet domestic demand.

Because melons are perishable, trade requires intensive care, planning, and investment such as reliable truck transportation and cold storage facilities, which translate into high transaction costs. As a result, trade in melons is largely limited to nearby countries like Vietnam,

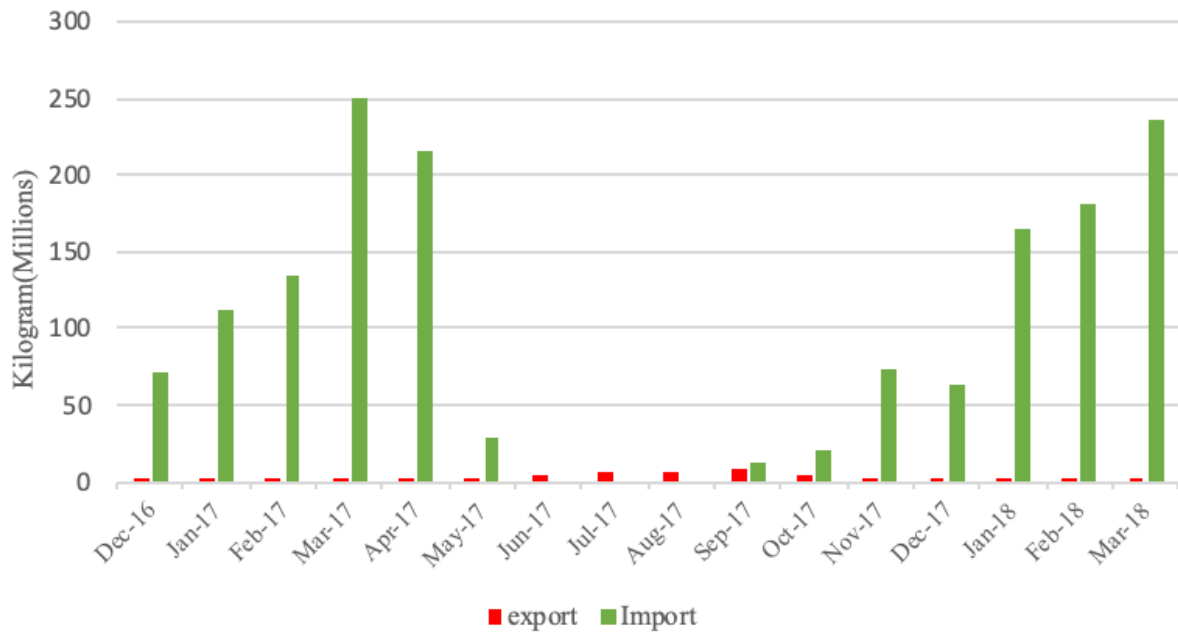
Thailand, Malaysia, and Taiwan (also known as ASEAN countries). Beginning in 2007, Myanmar was added to the list of the main exporters to China. Due to new trade agreements, horticultural commodity flow, including melons, along the China-Myanmar borderline increased at a rapid rate (Koji, 2016). Myanmar became the major exporter of melons to China, with the other major exporters being Vietnam and Malaysia (Figure 3). Although the types of melons produced are the same in all three countries, Malaysia exports fewer melons to China compared to Vietnam and Myanmar. Two possible reasons are: 1) Singapore is a major importer and Malaysia has a transportation cost advantage for shipping to Singapore, while Vietnam and Myanmar have a transportation cost advantage for shipping to China, and 2) the melon production season in Malaysia overlaps with the production season in China (Masdek & Muhammad, 2016).

Between November and April, the lowlands in Myanmar have ideal growing conditions for large-scale melon production. According to private communications with the Myanmar



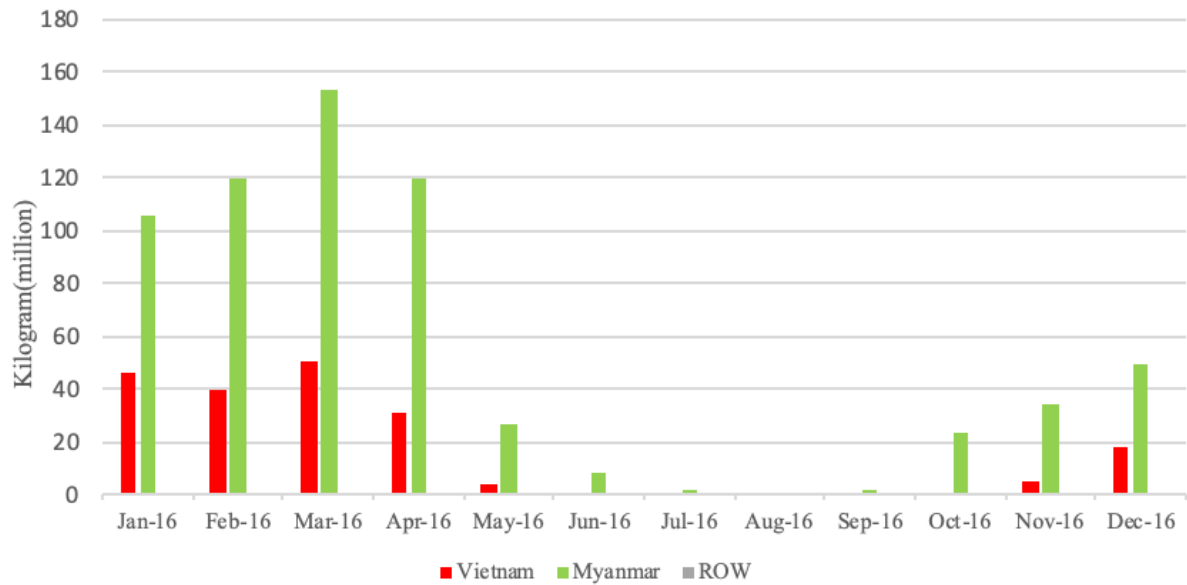
Note: The importing quantity of fruits in China market for the period of 2016 to 2018 was calculated using the data from the International Trade Center (2018).

Figure 1. Imported quantity shares of fruits in China (December 2016 - March 2018)



Note: Author's calculation using data from the International Trade Center (2018)

Figure 2. Export and import quantities of melons in China from December 2016 to March 2018



Note: ROW = rest of the world

Source: Author's calculation using data from the International Trade Center (2018). As the exporting amounts of 'ROW' are smaller than the amounts of Vietnam and Myanmar, they cannot be seen in the figure.

Figure 3. Major exporters of melons to China in 2016

Ministry of Commerce (MMC), there were approximately 150,000 melon farmers operating in the dry zone in the central part of the state of Shan in 2017. In addition, the MMC reports that nearly 70% of the total melon production in this

region of Myanmar is exported out of the country, mostly going to China, while the remainder is used for domestic consumption. Because of strong, continued international demand, helped in part by Myanmar's 2014

implementation of a national export strategy, melon production has been declared a national priority export crop.

Because melons did not appear on Myanmar's export radar until recently, much needed funding for production and marketing research was not available to better understand opportunities for expansion in production and international marketing. Having information about price and income elasticities of melons imported into China based on sources of origin can provide much needed information about the potential markets for melons produced in Myanmar and Vietnam. The objective of this study was to estimate the own-price, cross-price, and income elasticities of imported melons into China that were produced in Myanmar, Vietnam, and the rest of the world (ROW).

## Methodology

The demand of a commodity is affected by its own-price, prices of other commodities (cross-prices), and consumers' income. Different models such as the Armington model, the Rotterdam model, and the Almost Ideal Demand System (AIDS) model have been used to analyze the demand for commodities.

The Armington model is based on the strong assumption that goods are differentiated based on the country of origin and there is a constant elasticity of substitution among products. Nzaku *et al.* (2010) argued that imported fruits and vegetables should be treated as final goods as consumers use these goods in their fresh form. For such final goods, the AIDS and Rotterdam models are preferred over the less-flexible Armington model (Nzaku *et al.*, 2010).

The Rotterdam demand system (Selvanathan *et al.*, 2022) is a relevant competitor to the AIDS model. The AIDS model and its linear approximation (LA-AIDS) have many of the desirable properties of the Rotterdam system, however, with the addition of being derived from an expenditure function. A number of studies have been conducted to compare the Rotterdam and AIDS models. For instance, Taljaard *et al.* (2006) argued that the AIDS model was preferred over the Rotterdam for analyzing meat

consumption in South Africa. Li (2016) estimated U.S. import demand for mushrooms using both modeling approaches and concluded that their specification tests favored the AIDS model over the Rotterdam.

The AIDS model has been adopted by modelers to conduct demand system analysis for many different agricultural commodities (Nzaku *et al.*, 2010; Naanwaab & Yeboah, 2012; Zheng *et al.* 2019). Yang & Koo (1994) extended the AIDS model to estimate source-differentiated demand systems without all of the restrictions of the Armington system. Several studies have used this model to estimate price elasticities of demand for imported commodities from different exporting countries (Henneberry & Hwang, 2007; Tshikala & Fonsah, 2012; He, 2019; Mnatsakanyan & Lopez, 2019; Lee *et al.*, 2020; Ning *et al.*, 2021; Zhang *et al.*, 2021). We also used the source-differentiated AIDS model to estimate the own-price, cross-price, and income elasticities of imported melons in China from Vietnam, Myanmar, and ROW.

## AIDS model

The AIDS model developed by Deaton & Muellbauer (1980) is

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \log\left(\frac{M}{P}\right), \quad (1)$$

where,  $w_i$  is the budget share of the commodity,  $\alpha_i$  is the intercept,  $\gamma_{ij}$  represents own- and cross-price elasticities of commodity  $i$  to commodity  $j$ ,  $\beta_i$  is the coefficient of expenditure,  $M$  is the expenditure, and  $P$  is the price index. The price index used in Deaton & Muellbauer is nonlinear.

To make the estimation easier, researchers often use Stone's linear approximate price index (Green & Alston, 1990; Henneberry *et al.*, 1999; Taljaard *et al.*, 2006). Following Green & Alston (1990), the linear approximation of Stone's price index was used here. Cross-sectional studies often use quadratic AIDS and thus consider nonlinear Engel curves (Echeverría & Molina, 2022; Hovhannisyan *et al.*, 2022; Nava & Dong, 2022), but time series studies with small samples

sizes (Rathnayaka *et al.*, 2021) usually use linear functions of expenditure as was done here.

To estimate the demand system, three properties of demand are imposed. As outlined in Deaton & Muellbauer (1980), the first property is the summation, which requires the budget shares to add up to one. Summation requires that the sum of the intercepts is zero, the cross- and own-price elasticities sum to zero, and the sum of coefficients for expenditure,  $\beta_i$ , should equal zero. Mathematically, summation requires the following restrictions:

$$\sum \alpha_i = 1, \sum_i \gamma_{ij} = 0 \text{ and } \sum_i \beta_i = 0. \quad (2)$$

The second property of demand is homogeneity, requiring the demand functions to be homogenous of degree zero in prices and incomes, or

$$\sum_j \gamma_{ij} = 0. \quad (3)$$

The third property of demand requires the matrix of substitution effects to be symmetric, or

$$\gamma_{ij} = \gamma_{ji}. \quad (4)$$

Recall that China imports melons mostly during their off-season (November to April), so imports taper off in April and May when domestic farms start harvesting melons. This condition points out that there might be a seasonal effect on the demand for imported melons. To test this seasonal effect, seasonal dummy variables were included in the demand equation, which is rewritten as:

$$w_i = \sum_j \gamma_{ij} \log P_j + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3 + \alpha_4 D_4 + \beta_i \log\left(\frac{M}{P}\right), \quad (5)$$

where  $D_1$  represents the dummy variable for the first quarter ( $D_1$  (November to January),  $D_2$  for the second quarter (February to April),  $D_3$  for the third quarter (May to July), and  $D_4$  for the fourth quarter (August to October). As no intercept was included, all four dummy variables were included. The melon production season in China is from May to July and the data showed that imports of melons are low during this period. A joint F-test was conducted to test the null

hypothesis that all seasonal dummy variables are the same (i.e.,  $D_1 = D_2 = D_3 = D_4$ ).

Before the estimation of the LA-AIDS model, one equation must be dropped to avoid a singularity. The equation for ROW was removed from the analysis and its coefficients were calculated using the summation condition. After the LA-AIDS model was estimated, the coefficients were transformed to both Marshallian and Hicksian elasticities following past literature (Mdafri & Brorsen, 1993; Taljaard *et al.*, 2004; Tshikala & Fonsah, 2012):

$$\epsilon_{ii}^M = -1 + \frac{\gamma_{ii}}{w_i} - \beta_i \quad (6)$$

$$\epsilon_{ij}^M = \frac{\gamma_{ij}}{w_i} - \beta_i \left(\frac{w_j}{w_i}\right) \quad (7)$$

$$\epsilon_{ii}^H = -1 + \frac{\gamma_{ii}}{w_i} + w_i \quad (8)$$

$$\epsilon_{ij}^H = \frac{\gamma_{ij}}{w_i} + w_j \quad (9)$$

$$\eta_i = 1 + \frac{\beta_i}{w_i} \quad (10)$$

The Marshallian elasticities ( $\epsilon^M$ ) are conditional elasticities and are derived from cross-price elasticities and budget shares as per equations (6) and (7), the Hicksian elasticities ( $\epsilon^H$ ) or compensated elasticities are calculated per equations (8) and (9), and the expenditure elasticities ( $\eta_i$ ) are calculated per equation (10). The Marshallian demand elasticities are conditional elasticities in that they are conditional on the total expenditure on melons. See Carpenter & Guyomard (2001) for one approach of how to convert conditional elasticities to total elasticities.

### Separability test

The source-differentiated AIDS model of Yang & Koo (1994) is a variation of the AIDS

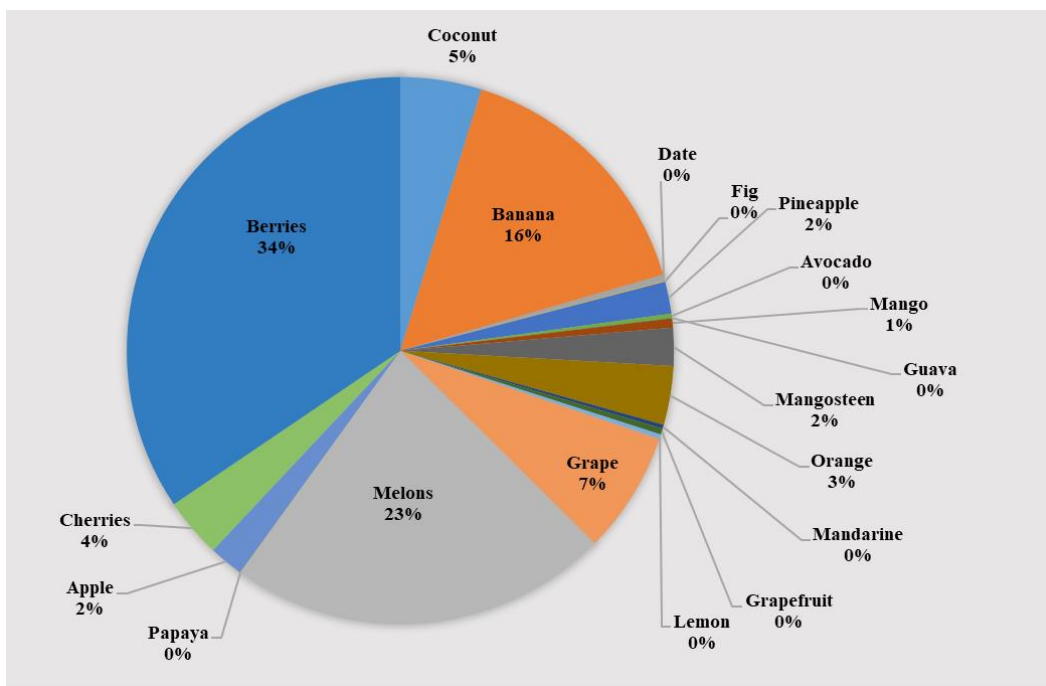
model where commodities from different countries are treated as different products and additional separability is imposed and tested. Deaton & Muellbauer (1992) explained the concept of separability among commodities using a multi-stage budgeting concept. In multi-stage budgeting, expenditure is divided among different groups of commodities such as food and non-food groups. Here, fruits were divided into different groups and melons were divided into three groups depending on where they were produced. There are two types of separability: strong separability and weak separability. With weak separability, the marginal rate of substitution between melons from these countries does not depend on the prices of other types of fruit. With strong separability, which was not considered, the marginal rate of substitution between Vietnamese and Myanmar melons would not depend on the price of melons in the rest of the world.

It is important to test weak separability because it determines whether the demand for melons by source can be considered without including the prices of other fruits (Yang & Koo, 1994). The null hypothesis of weak separability between melons and other fruits was tested by

examining whether the marginal rate of substitution (MRS) between two commodities in the same group is independent of the quantity consumed of commodities in other groups. If the test indicates weak separability, then the number of parameters in the demand system can be reduced.

Previous studies have estimated similar demand systems and tested separability between the studied product/commodity and its related products. For example, Henneberry *et al.* (1999) found that fresh fruits, meats, and vegetables were all separable from each other. Naanwaab & Yeboah (2012) found U.S. demand for fresh vegetables was separable from fresh fruits and other food commodities. In this study, we also assumed separability of the food group from the non-food group. We further assumed separability between fruits and other food groups. We tested separability between melons and other imported fruits. Because the study period data reflected the off-production season in China, domestically produced melons in China were not considered.

According to **Figure 4**, the major imported fruits during the study period were bananas, grapes (*Vitis*), melons, and different berries



**Figure 4.** Quantity share of fruits during the melon import season  
 Source: Author's calculation using data from the International Trade Center (2018)

including strawberries (*Fragaria × anassa*), which accounted for 16%, 7%, 23%, and 34% of the total quantity of imported fruits, respectively. Imported fruits with very low import quantities, such as dates (*Phoenix dactylifera*), mangoes (*Mangifera Indica*), and lemons (*Citrus limon*), were not included in this study. Thus, the separability test was conducted with the hypothesis that melons are separable from other major imported fruits.

The separability hypothesis was tested following Moschini *et al.* (1994). Mathematically, the utility function for the tested hypothesis is written as:

$$U = U^0 [q_1, f(q_2, q_3, q_4)] \quad (11)$$

where  $U$  is the utility function for imported fruits,  $q_1$  is the quantity of melons,  $q_2$  is the quantity of berries,  $q_3$  is the quantity of bananas, and  $q_4$  is the quantity of grapes. For this utility function, the separability restrictions set the ratio of the elasticities of substitution ( $\pi_{i,j}$ ) equal to a ratio based on expenditure elasticities. For an Almost Ideal Demand System (AIDS) model with four variables, separability requires three such conditions:

$$\frac{\pi_{1,2}}{\pi_{1,3}} = \frac{\theta_2}{\theta_3}, \frac{\pi_{1,3}}{\pi_{1,4}} = \frac{\theta_3}{\theta_4}, \frac{\pi_{1,4}}{\pi_{1,2}} = \frac{\theta_4}{\theta_2} \quad (12)$$

where the restrictions denoted in equation (12) can be written as:

$$\frac{(\gamma_{i,j} + w_i w_j)}{(\gamma_{i,k} + w_i w_k)} = \frac{(w_j + \beta_j)}{(w_k + \beta_k)}, \quad (13)$$

where,  $\gamma_{i,j}$  is the cross-price elasticity of “ $i$ ” with “ $j$ ”, “ $w$ ” represents the budget share, and  $\beta_j$  represents the expenditure elasticity of “ $i$ ”.

The unrestricted and restricted models, were estimated using PROC MODEL in SAS, and the likelihood ratio test was used to test the above hypothesis. Under the null hypothesis, the  $LRT$  has an asymptotic chi-squared distribution.

### Endogeneity test

In the AIDS model, the dependent variable (budget share) is calculated based on the total expenditure. The total expenditure variable is also included as a right-hand-side variable (independent variable). Thus, endogeneity might exist when estimating the parameters of the LA-

AIDS model (Bakhtavoryan *et al.*, 2018, 2022; Hejazi *et al.*, 2019; Cheng *et al.*, 2021; Zhai *et al.*, 2022). Therefore, expenditure endogeneity in equation (1) was tested using the method described by Greene (2018). Instrumental variables can be used if endogeneity is present (Lei *et al.*, 2021; Lindström, 2022).

To conduct the endogeneity test, the potential endogenous variable, expenditure, is regressed against the lag of quantity and prices of imported melon from different sources and the residuals are computed. Then, these residuals are added to the LA-AIDS model as extra explanatory variables. Non-significant parameters of the residuals suggest failure to reject the null hypothesis of no endogeneity.

### Data collection and analysis

The trade data on different fruits collected from the International Trade Center (ITC) (2018) website were monthly imported quantity (kilograms) and imported value (USD). The ITC data were collected by the China Customs Department. The study period was from December 2007 to March 2018. Exporters were listed as Vietnam, Myanmar, and ROW. Countries that had less than 10% of the total import amount were included in the ROW category. Few melons are imported to China during June through the beginning of September; the primary time of year when melons are harvested from China’s domestic farms. Thus, data from the months of June, July, and August were removed from the dataset. The dataset had 107 total monthly observations for each variable.

The unit value of each commodity was calculated by dividing the aggregated import value by the aggregated quantity of the imported commodity. There were some missing values for the imported quantity of melons from Myanmar from 2015 to 2018. To impute missing values, the average monthly price of melons in the Muse border trade zone (Yuan per kilogram), and the exchange rate (Yuan per USD) were used to estimate an equation in which the dependent variable was the unit value of melons in China (USD per kilogram). Descriptive statistics for melon price (USD per kilogram) and the expenditure share of melons from each exporter are shown in **Table 1**.

**Table 1.** Summary statistics for prices and budget share for imported melons into China

Variable/Country	Mean	SD	Min	Max
<i>Price</i>				
Vietnam	0.195	0.032	0.130	0.286
Myanmar	0.064	0.018	0.04	0.095
ROW	1.310	1.055	0.037	5.618
<i>Budget share</i>				
Vietnam	0.645	0.264	0.098	1
Myanmar	0.531	0.343	0.0002	1
ROW	0.049	0.133	0.0001	0.724

The estimated parameters for the border market price and exchange rate are reported in **Table 2**. The export quantity and value data from Myanmar were missing for some months during 2015 to 2018. Therefore, the average monthly price of melons in the Muse border trade zone (Pmm, Unit- Yuan per Kilogram) and the exchange rate (Pex, Unit- U.S. \$ per Yuan) were used to estimate the unit value of melons in the China market (Pcc, Unit – U.S. \$ per Kilogram). Then, the calculated unit value in the China market and the monthly exported quantity of melons from Myanmar side were used to impute the missing values.

Note that the price of Myanmar melons was considerably lower than the prices for Vietnam or ROW. The melon category includes different types of melons such as cantaloupe, muskmelons, and watermelons. In practice, however, melon prices vary based on cultivar. Differences in the types of melons imported could explain the price differences. Another source could be measuring the prices at different points in the marketing channel and so the prices for Vietnam and ROW may have more transportation costs included.

## Results and Discussion

### Fairness and transparency of the direct PFES program

The first step in the analysis was to determine if melon demand can be considered separable from the demand for other fruits. The likelihood ratio (LR) tests of separability are reported in **Table 3**. The LR statistics for grapes

and bananas were 2.466 and 0.2936, respectively. Since both LR statistics are smaller than the chi-square critical value with 1 degree of freedom of 3.84, it was determined that the demand equation for grapes and bananas (the two other major fruits in the data) could be dropped from the LA-AIDS model because they could be separated apart from melons. Note that this type of separability restriction was rejected for meat demand by Henneberry & Hwang (2007), so fruit demand is less intertwined than meat demand.

The tests for endogeneity of the share of expenditure on melon between exporting countries (i.e., Vietnam, Myanmar, and ROW) are reported in Table 4. The Wald statistic showed that the estimated parameters for residuals in all three demand equations could not be rejected,  $P = 0.28, 0.66,$  and  $0.77$  for the Vietnam, Myanmar, and ROW equations, respectively. Since the null hypothesis of exogeneity was not rejected, the LA-AIDS model was estimated without using IV for expenditure. From the past literature (LaFrance, 1993), we know that endogeneity is a concern, and, so, what these results show is that using an IV estimator would not have changed the conclusions.

The parameter estimates, Marshallian price and income elasticities, and Hicksian price elasticities are reported in **Table 5**. The results suggested that the estimated parameters for expenditure of Vietnamese and Myanmar melons were statistically significant with positive coefficients. All income elasticities were positive and statistically significant except for the 'ROW' melons. Melons from the 'ROW' were less



**Table 2.** Estimated parameters for the unit value of melons imported to China from Myanmar as a function of the China-Myanmar border market price and exchange rate

Variable	Parameter	SE	R-square
Border market price	0.002	0.012	0.62
Exchange rate	0.47	0.7	

**Table 3.** Separability test

LR statistic	DF	Critical Value (P=0.05)
Demand equation "grape" is dropped. 2.466	1	3.84
Demand equation "banana" is dropped. 0.2936	1	3.84
Demand equation "berry" is dropped. 2.7774	1	3.84

**Table 4.** Expenditure endogeneity test

Demand equation	Wald Statistic	P-value
$w_{vi}$	1.58	0.208
$w_{mm}$	0.18	0.66
$w_{row}$	0.09	0.7685

Note:  $w$  is budget share,  $vi$  = Vietnam,  $mm$  = Myanmar,  $row$  = rest of the world. The dependent variable "budget share" is calculated based on the total expenditure which is also included in right-hand-side variables. Thus, the expenditure endogeneity in the demand equation was tested by the method described in Greene (2018).

income elastic as compared to the other two sources, indicating ROW melon demand tends to be determined by other factors.

The absolute value of the conditional Marshallian (uncompensated elasticities) and the Hicksian or compensated elasticities for both Vietnam and Myanmar were near or above one indicating their demand as being price-elastic (Taljaard *et al.*, 2004; Tshikala & Fonsah, 2012) while holding melon expenditures constant. The own-price Marshallian elasticities of melons had negative signs, and all were statistically significant. The expenditure elasticities for Myanmar and Vietnam were both near one indicating their melons are similarly desired and both are preferred to melons from other countries as a way to meet rising demand.

The cross-price elasticities could provide useful information on the relations between commodities (Yang & Koo, 1994). The Marshallian cross-price elasticities for Vietnamese and Myanmar melons suggest that

melons produced in Myanmar and Vietnam are strong substitutes for each other. The cross-price elasticity between "ROW" melons and the other two sources was not statistically significant. Thus, in developing marketing plans both Vietnam and Myanmar have little need to look beyond each other in evaluating their primary competition.

The quarterly dummy variables in the demand equations for melons did not show much variation indicating little seasonality in the import shares of these countries. Thus, when planning production strategies, demand remains strong during the entire production season for Myanmar and Vietnam. This strong demand could be due to China not producing melons during this period and lower transportation costs preventing other countries from competing. This means that Vietnam and Myanmar could both benefit from increasing their production at the beginning and end of their current production season.

**Table 5.** Estimated parameters, and Marshallian and Hicksian elasticities of source-differentiated melon demand for imports into China

Variable	Vietnam	Myanmar	ROW
$P_{vi}$	-0.180***	0.170***	0.010
$P_{mm}$	0.177***	-0.159***	-0.011
$P_{row}$	-0.021	-0.0112	0.001
Exp	-0.007***	0.033**	-0.02***
$D_1$	0.8165**	-0.25	0.436***
$D_2$	0.993***	-0.461	0.468***
$D_3$	0.727**	-0.130	0.402***
$D_4$	0.650**	-0.020	0.370***
<i>Marshallian Elasticity</i>			
Vietnam	-1.37*** (-25.41)	0.365*** (6.38)	0.022 (0.90)
Myanmar	0.311*** (5.85)	-1.354*** (-23.50)	0.088** (3.20)
ROW	0.414 (1)	0.063 (0.17)	-0.024** (-1.23)
Income	0.984*** (30.78)	1.067*** (34.18)	0.058 (0.31)
<i>Hicksian Elasticity</i>			
Vietnam	-1.855*** (-32.19)	0.350*** (6.32)	0.049 ** (2.02)
Myanmar	0.37*** (7.14)	-0.824*** (-15.07)	0.005 (0.26)
ROW	0.845** (2.03)	0.0922 (0.26)	-0.937 (-2.10)
Joint F-test	15.40**	22.87***	29.09***

Note:  $P$  = melon price,  $Exp$  = expenditure,  $D_1$  = dummy variable for first quarter of the season which is from November to January,  $D_2$  = dummy variable for second quarter of the season which is from February to April,  $D_3$  = dummy variable for third quarter of the season which is from May to July, and  $D_4$  = dummy variable for fourth quarter of the season which is from August to October.

## Conclusions

Chinese melon imports are dominated by Myanmar and Vietnam. China's melon production is in the summer months and its imports are in the offseason when China is not

producing melons. The results show that Vietnam and Myanmar are strong competitors with each other for China's market for melon imports. Vietnam and Myanmar both had similar own-price elasticities and similar expenditure

elasticities. They also had large cross-price elasticities, indicating that their melons are strong substitutes for one another. Moreover, melon imports from other countries around the world do not appear to have much impact on imports from Vietnam and Myanmar.

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