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# EUROPEAN DEMAND FOR ORANGE JUICE

BY

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## European Demand for Orange Juice

The demand relationship for orange juice (OJ) in the European market has been difficult to estimate due to the lack of good data, particularly on retail sales. Data on imports and exports, though, have provided some insight. For example, based on Brazil export data, Brown, Spreen and Lee estimated the own-price elasticity for OJ demand in Europe at  $-0.41$  at the FOB level (2004). Such estimates can be important for market analysis as indicated in the latter study which examined the potential impact of lowering world OJ tariffs on U.S. OJ prices.

Brazil export data were used by Brown, Spreen and Lee, given Brazil is the dominant supplier of OJ to Europe, as well as other world markets. An alternative approach, however, would be to estimate Europe's demand for OJ based on import data. Global Trade Information (GTI) provides various import and export data for Europe (EU-15) and other countries in the world. Data on the total quantity of OJ imported into the EU, though, is problematic as the degree Brix<sup>1</sup> or level of concentration is not clear for some of the product imported. Thus, it is difficult to determine, say, the total number of single strength equivalent gallons (11.8 degree Brix) that Europe imports. Nevertheless, Europe's OJ demand can be examined based on reported dollar values for the imports, along with data on the price for the major category, frozen concentrated orange juice (FCOJ). Prices for different OJ products tend to be highly correlated and one approach is to use the FCOJ price as proxy for other OJ prices.

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<sup>1</sup> Brix is the percent of product by weight that are solids (sugar, vitamin C, etc.). For example, in a 66<sup>0</sup> degree Brix metric ton (2,204.6 lbs.) there are 1,455 pound solids (2,204.6 times .66).

## Model

The demand for OJ in terms of expenditures can be written as

$$(1) \quad \log(pq) = a + (\varepsilon+1) \log(p),$$

where  $p$  and  $q$  are the overall price and quantity of OJ;  $pq$  is the total expenditures on OJ;  $\varepsilon$  is the own-price elasticity; and  $a$  is a constant.

Although data on total OJ expenditures are available, data on the overall OJ price  $p$  are not. However, data on the price for FCOJ, denoted by  $p_1$ , are available. Given the prices for OJ products tend to be highly correlated, consider using the price of FCOJ as a proxy for the overall OJ price in equation (1), i.e.,

$$(2) \quad \log(pq) = a + (\varepsilon+1) \log(p_1),$$

or

$$(3) \quad \log(pq/p_1) = b + \varepsilon \log(p_1).$$

In equation (3), the dependent variable is the log of total expenditures on OJ ( $pq$ ) divided by the FCOJ price ( $p_1$ ), and the price variable is the FCOJ price ( $p_1$ ), as opposed to overall price  $p$  in equation (1). The own-price elasticity  $\varepsilon$ , however, is the same in both equations (1) and (3).

The data on prices and expenditures are in dollars, but, since demand occurs in Europe, actual prices paid are in terms of Euros. Thus, the dollar prices were transformed to Euro prices based on the Euro/\$ exchange rate  $r$ , i.e.,

$$(4) \quad \log(pq/p_1) = b + \varepsilon \log(rp_1).$$

Note that  $r$  vanished in the dependent variable as both expenditures and prices are multiplied by  $r$ :  $(rpq)/(rp_1) = (pq)/(p_1)$ .

Thus, as an approximation, equation (4) is used to estimate the own-price elasticity of demand.

### **Data**

Annual GTI data from 1997 through 2009 (13 observations) were analyzed. The dependent variable was the total value of OJ imports into the EU-15 divided by the Brazil FOB price for FCOJ, while the independent variable was the Brazil FCOJ price. The EU-15 price for apple juice imports (GTI), OJ production in the EU (Spain, Italy and Greece), a trend variable (a proxy for preferences as well as European income which has tended to growth over the time period studied) and two dummy variables for the recent downturn in the U.S., European and world economies were also considered as an explanatory variable in equation (4), but none were insignificant. Since the FCOJ price is being used as a proxy for the overall price for OJ, the instrumental variable method was used to estimate equation (4). The instruments were the log of Florida beginning OJ inventories, the log of Brazil beginning OJ inventories, the log of U.S. OJ production; the log of Brazil OJ production (Florida Department of Citrus); and time. The instruments selected are primary exogenous variables underlying OJ prices.

### **Results**

The ordinary least squares (OLS) estimate of equation (4) is

$$(5) \quad \log (pq/p_1) = 7.322 - .445 \log (rp_1).$$

The p-values (probabilities greater than the absolute values of the t-statistics) for the intercept and the price elasticity were <.0001 and .0054, respectively. The r-square was .52. Autocorrelation did not seem to be a problem with the Durbin Watson statistic at 2.212.

The instrumental variable (IV) estimate of equation (4) is

$$(6) \quad \log (pq/p_1) = 7.353 - .677 \log (rp_1).$$

The p-values for the intercept and the price elasticity were <.0001 and .0238, respectively. The r-square was .38.

The OLS estimate of the own-price elasticity is similar to the earlier estimate made by Brown, Spreen and Lee. The IV estimate, however, suggests the elasticity could be larger (in absolute value). These elasticities are at the FOB price level, and corresponding retail price elasticities would be expected to be greater. Letting  $p_r$  be the retail price, an estimate of the elasticity at the retail level is  $\epsilon(p_r/p)$ , assuming the slope and quantity are the same at both FOB and retail levels, i.e.,  $\epsilon(p_r/p) = (\partial q/\partial p)(p/q)(p_r/p) = (\partial q/\partial p)(p_r/q)$ .

### **Transshipments of OJ**

Some of the OJ imported into the EU-15 is eventually re-exported to other countries such as Russia. Thus, equations (4) through (6) not only reflect demand for OJ in Europe but also demand in export markets at least to some degree (exported product may originate not only from imports but also from European OJ production). To account for exports, the following model was also considered.

$$(7) \quad pq = p(q_d + q_e),$$

$$(8) \quad pq = p(c + dp) + pq_e$$

$$(9) \quad pq = p_1(c + dp_1) + (p/p_e)p_e q_e$$

$$(10) \quad pq/p_1 = c + dp_1 + e(p_e q_e/p_1)$$

$$(11) \quad pq/p_1 = c + dp_1 + e(p_e q_e/p_1),$$

where  $q_d$  and  $q_e$  are the quantities of imports consumed in the EU-15 and re-exported, respectively;  $p_e$  is the export price and  $p_e q_e$  is the export value; and  $c$ ,  $d$  and  $e$  are parameters to be estimated. Equation (7) decomposes the total quantity of imports ( $q$ ) into the amounts domestically consumed ( $q_d$ ) and exported ( $q_e$ ). Equation (8) assumes domestic consumption is a

linear function of price. Equation (9) uses the FCOJ price ( $p_1$ ) as a proxy for  $p$  in describing domestic demand on the right-hand-side of the model, and the export term is multiplied and divided by the export price ( $p_e$ ). Equation (10) is obtained by dividing both sides of equation (9) by the FCOJ price ( $p_1$ ), and assuming the ratio of the import price ( $p$ ) to the export price ( $p_e$ ) is constant ( $e$ ). Equation (11) introduces the exchange rate ( $r$ ) as in the case of model (4).

The ordinary least squares (OLS) estimate of equation (11) is

$$(12) \quad pq/p_1 = 2094.063 - 564.057 (rp_1) + -.028 (p_e q_e / p_1)$$

The p-values for the intercept, the price coefficient and the export variable were  $<.0001$ ,  $.0057$ , and  $.951$ , respectively. The r-square was  $.56$  and the Durbin Watson statistic was  $2.00$ .

The instrumental variable (IV) estimate of equation (4) is

$$(13) \quad pq/p_1 = 2297.962 - 740.442 (rp_1) + -.019 (p_e q_e / p_1)$$

The p-values for the intercept, the price coefficient and the export variable were  $<.0001$ ,  $.0223$ , and  $.971$ , respectively. The r-square was  $.50$ . The same instruments as used in estimating equation (4) were used to obtain equation (11), except actual values were used as opposed to log values.

Thus, both the OLS and IV estimates of the export coefficient  $e$  were statistically insignificant, while the price coefficient  $d$  was statistically significant based on both estimation methods.

Since the model is linear the price elasticity is  $\varepsilon = \partial(pq/p_1)/\partial(rp_1)(rp_1)/(pq/p_1) = d(rp_1)/(pq/p_1)$ . At sample means ( $rp_1 = 1.16$  and  $pq/p_1 = 1433.73$ ),  $\varepsilon = -.46$  and  $-.60$ , based on the OLS and IV methods, respectively. These elasticity estimates are similar to those based on the log model not corrected for exports. Thus, neither functional form nor treatment of exports appears to be critical for analysis of these specific data.

**Concluding Remarks**

The demand for OJ in Europe, and in particular the own-price elasticity of demand, has been difficult to estimate due to lack of good data. Europe, however, is the largest OJ market in the world (USDA, Foreign Agricultural Service), and cannot be ignored in analyzing the U.S. and Florida OJ situations, given OJ is an internationally traded commodity. Thus, estimates of the impacts of factors such as own-price on Europe's OJ demand are critical for understanding the market. The estimates in this study, although rough, provide some guidance for the magnitude of the price response in Europe, but to keep them in perspective, they are based on a relatively small number of observations and a proxy variable, suggesting that, as more and hopefully better data become available, further research on this topic are needed.