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United States Demand for Coffee Imports

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Abstract

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The United States – one of the world's largest coffee importers – imports coffee beans from a variety of different countries. These countries are aggregated into five groups representing five broadly defined types of coffee. Imports of the five coffees over time are examined to determine price, expenditure and substitution elasticities. These elasticities reflect preferences as well a technical relationships in the form of blending recipes. The lower the degree of substitutability between the different types of coffee, the more inelastic the demand from the United States facing groups of exporting countries.

The results suggest rigidities in United States imports of coffee of different types. These rigidities are evidenced by substantial complementarity among the five coffee types. Preference patterns are very similar across a wide range of model specifications. There are differences in expenditure elasticities for different types of coffee in the United States.

Introduction

Two major types of coffee are produced and traded: arabicas and robustas. Arabicas are grown at high altitudes and have a milder taste. Robustas are grown at lower altitudes and taste bitter but they are more suitable for making instant coffee as they produce a higher volume for a unit weight of beans. On average, arabica prices are 10% higher than robusta prices.

Arabicas can further be divided into Colombian milds, unwashed arabicas, and other milds. Colombian milds are washed high-quality arabicas preferred by North Europeans; they are the arabicas produced in Colombia, Tanzania and Kenya. Unwashed arabicas, produced in Brazil and Ethopia, are arabicas that are sun-dried and thus do not go through the washing process; they are relatively bland and are usually lower priced than washed arabicas. Other milds

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refer to all other washed arabicas. They are very similar to Colombian milds but are usually priced somewhat below Colombian milds.

Robusta can be sub-divided into those from Indonesia and those from the rest of the world. Indonesian robustas are of inferior quality and usually are priced 5–10% below other robustas.

The five types of coffee which are blended by roasters are substitutable to some extent, especially in the long run. Price differentials among the types fluctuate from one year to another depending on the supply and demand of each type of coffee. Price-conscious blenders attempt to find the right mix to minimize cost while maintaining quality and taste.

Price, expenditure and substitution elasticities for the different types of coffee reflect preferences as well as technical relationships in the form of blending

TABLE 1

Grouping of U.S. coffee imports by source into coffees of the same type

(1)	Ararabic - Other Milds		
	Burundi	Honduras	Argentina
	Papua, New Guinea	Nicaragua	Bolivia
	Costa Rica	Haiti	Chile
	Dominican Republic	Jamaica	Mexico
	Ecuador	Panama	Guatemala
	El Salvador	Neth. Antilles	Fed. Rep. Germany
	Rwanda	Paraguay	Italy
	Peru	Venezuela	Netherlands
	Israel	Canada	Bulgaria
	Belgium-Luxembourg	France	India
(2)	Arabica - Colombian Mild		
	Kenya		
	United Republic of Tanzania		
	Columbia		
(3)	Arabica - Unwashed		
	Ethiopia		
	Brazil		
(4)	Robusta		
	United Republic of Cameroon	Liberia	Guyana
	Angola	Madagascar	Malaysia
	Zaire	Sierra Leone	Philippines
	Equatorial Guinea	Guinea	Thailand
	Ghana	Uganda	China
	Ivory Coast	Belize	
(5)	Robusta		
	Indonesia		

Source: U.N. trade data tapes.

TABLE 2

U.S. import expenditure shares for the major types of coffees

	Arabica			Robusta	
	Colombian mild	Other mild	Unwashed	Indonesia	Other countries
1962	0.27	0.25	0.40	0.01	0.07
1963	0.26	0.23	0.42	0.02	0.07
1964	0.20	0.27	0.36	0.01	0.16
1965	0.20	0.29	0.34	0.02	0.15
1966	0.17	0.27	0.35	0.02	0.19
1967	0.18	0.27	0.34	0.03	0.18
1968	0.16	0.24	0.36	0.03	0.21
1969	0.16	0.28	0.34	0.04	0.18
1970	0.17	0.29	0.31	0.03	0.20
1971	0.15	0.26	0.33	0.04	0.22
1972	0.17	0.27	0.34	0.03	0.19
1973	0.18	0.33	0.28	0.02	0.19
1974	0.20	0.34	0.18	0.05	0.23
1975	0.22	0.35	0.24	0.02	0.17
1976	0.17	0.41	0.22	0.04	0.16
1977	0.17	0.44	0.18	0.05	0.16
1978	0.20	0.41	0.19	0.05	0.15
1979	0.22	0.50	0.13	0.05	0.10
1980	0.21	0.39	0.24	0.05	0.11
1981	0.13	0.39	0.28	0.07	0.13
1982	0.13	0.41	0.24	0.06	0.16
1983	0.13	0.42	0.25	0.07	0.13
1984	0.14	0.43	0.25	0.05	0.13

Source: U.N. trade data tapes.

recipes. The lower the degree of substitutability between the different types of coffee the more inelastic the demand facing exporters of coffee.

The United States of America is the world's largest importer of coffee with its imports ranging between 27 and 45% of total world imports over the period 1964–1982. The U.S. share has been declining over the period. The United States re-exports only a small percentage of its coffee imports (about 7%). U.S. imports come from a large number of exporting countries. The imports from certain countries can be aggregated to characterize imports of the five major coffee types (see Table 1). In Table 2 the import expenditure shares of each of the five coffee types over the period of the analysis are presented. The expenditure shares for each of the major types of coffee have been changing over the period: for example, the expenditure share of other mild arabicas has increased with the other two arabicas declining. At the same time, there has been an increase in the expenditure share of robustas from Indonesia. The

critical question of the implications of changing import shares for coffee exporters remains unanswered.

A detailed examination of U.S. imports of the five major types of coffee can provide information to coffee producers about this market for their products. While the United States is not the only coffee importer, its size in world markets makes it of key importance. The determination of the demand, price and substitution elasticies in the U.S. market can provide exporters with a partial base for developing marketing strategies.

The objectives of this research project are to estimate the demand for coffee in the United States in aggregate, and disaggregated by type of coffee; to estimate elasticities of substitution between different coffees in the United States; and to simulate the impact of exogenous shocks to United States coffee imports.

Model specification

In considering the demand for most agricultural products, it is possible to characterize the demand as either final consumer demand (since the processing of most agricultural products does not change the nature of the good, only its form, e.g. carcass beef is processed into beef cuts, coffee beans are processed into instant coffee) or input demand by the processing sector (e.g. coffee roasters blend different types of coffee beans to produce one brand of instant coffee). In specifying models to depict either type of demand, the structure of the final estimated model may not differ drastically but the interpretation and constraints implied by economic theory may be different. For example, it may be reasonable to test for or impose homogeneity on a cost function and the derived input demand system (implying a constant return to scale production technology) but not as reasonable to impose homogeneity on a utility function and the derived consumer demand system (implying linear expansion paths through the origin for demand for goods as income varies with prices constant).

The model developed to examine the factors determining the United States imports of the five major types of coffee is a two-stage estimation problem. In the first stage, the aggregate coffee expenditure (or import expenditure on coffee since the United States does not produce coffee) is considered the solution of a consumer choice problem determining expenditure (demand) on coffee with respect to prices of all other goods and disposable income. In the second stage, demands for different types of coffee are determined with respect to prices of different types of coffee and total expenditure on coffee. This two-stage procedure rests on an assumption of weak separability between coffee and all other goods (i.e. that the marginal rate of substitution between any two types of coffee is independent of the quantities of any other goods consumed or other inputs used).

Since the primary focus of the research is the determination of demand characteristics at the second stage of estimation of the model, the first stage is

expressed as a relatively simple direct relationship between expenditure, prices and other explanatory variables:

$$\text{TEXP} = f(P, Y, Z) = \sum_i P_i X_i$$
$$P = \frac{\sum_i P_i X_i}{\sum_i X_i} \quad \text{for each time period} \tag{1}$$

where TEXP is total expenditure on coffee; P the quantity weighted price of the different types of coffee; $i = 1, 2, \ldots, n$ is number of types of coffee; X_i quantity of each type of coffee; Y the disposable income; and Z other exogenous shifters.

The homogeneity restriction of consumer theory can be adhered to by deflating all the monetary variables using an appropriate price index. It is important to note that it is not possible to sign the relationship between price and total expenditure; a relationship positive but less than one (in log-log form) would only imply inelastic demand for the aggregate commodity.

Two different model specifications are tested for the second stage of the model to establish parameter robustness:

1 (a) A demand system derived from an indirect utility function with a translog functional form (Christensen and Manser, 1977)
  (b) A demand system derived from an indirect utility function with a translog functional form allowing for time as an additional explanatory variable.
2 (a) An AIDS demand system (Deaton and Muelbauer, 1980, 1981)
  (b) An AIDS demand system allowing for time as an additional explanatory variable.

Time is included in the demand systems as an additional explanatory variable to test the hypothesis that tastes and preferences have evolved over time – using the methodological approach developed by Jorgenson and Lau (1975) and McKay et al. (1983). The demand systems to be estimated are portrayed in Table 3.

The demand systems are expressed in terms of expenditure shares for different types of coffee. Because the expenditure shares must sum to one, only $n-1$ of the equations are independent. The share equations may also be assumed to have additive disturbances with a joint normal distribution. Woodland (1979) has addressed the problem of assuming that share equations have joint normal distributions (dependent variables confined to the 0–1 quadrant) and concludes that although the normal distribution may not be a theoretically appropriate specification it may, for a large number of data sets, yield valid results. The budget share equations for the translog models are homogeneous of degree zero in the parameters, hence normalization of the parameters is required for estimation. The normalization used herein is:

$$\sum_i \alpha_i = -1$$

TABLE 3

Expenditure share models

1 (a) Translog model (without time)

$$\frac{p_i q_i}{m} = \frac{\alpha_i + \sum_j \beta_{ij} \ln P_j^*}{\sum_i \alpha_j + \sum_i \sum_j \beta \ln P_j^*} \qquad \text{for} \quad i, j = 1, ..., n$$

where

$$\beta_{ij} = \beta_{ji}, \quad P_j^* = \frac{P_j}{M}, \quad m = \sum p_i q_i$$

m total expenditure on coffee
p_i price of coffee of type i
q_i quantity of coffee of type i
n number of types of coffee

(b) Translog model (with time)

$$\frac{p_i q_i}{m} = \frac{\alpha_i + \sum_j \beta_{ij} \ln P_j^* + \beta_{it} \ln t}{\sum_i \alpha_j + \sum_i \sum_j \beta_{ij} \ln P_j^* + \sum_i \beta_{it} \ln t} \qquad \text{for} \quad i, j = 1, ..., n$$

where

t linear time trend

2 (a) AIDS model

$$\frac{p_i q_i}{m} = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln (m/P) \qquad \text{for} \quad i, j = 1, ..., n$$

where P approximated by:

$$\ln P^* = \sum_k W_k p_k$$

P price index
W_k budget share

(b) AIDS model (with time)

$$\frac{p_i q_i}{m} = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln (m/P) + \gamma_{it} \ln t \qquad \text{for} \quad i, j = 1, ..., n$$

where

$$\sum_i \gamma_{it} = 0$$

Data

The data used in the analysis are from the U.N. trade data system (annual data, 1962–1984). The U.S. imports of coffee are from Standard International Trade Classification (SITC) category 0.711 (coffee, green, roasted). The quantities of the various types of coffee are expressed on a per-caput basis by dividing by the United States population (International Monetary Fund Financial Statistics). Total expenditure on coffee imports are derived (again on a per-caput basis) by summing the products of per-capita quantities and import unit values (total value of imports from each group of countries divided by total quantity of imports from each group of countries). Data on disposable income for the United States was taken from the International Monetary Fund Financial Statistics and expressed on a per-caput basis by dividing by population. For the second stage, import unit values (prices) for each coffee type were normalized by dividing by per caput expenditure in accordance with the models specified in Table 3. For estimation purposes the normalized prices were scaled to equal 1.0 in 1973, the midpoint of the sample. Parameter estimates are not invariant to such a rescaling. However, it has been shown by Christensen and Manser (1977) that price, expenditure and substitution elasticities are all invariant to such a multiplicative scaling of the data when using the translog system. For comparative purposes the data was similarly manipulated when the AIDS model was used.

Results

The results of the estimation of the first stage of the model are reported in Table 4. The model was estimated in logarithmic form for purely pragmatic reasons, i.e. the fit was better than for the linear form. The results suggest the aggregate demand for coffee in the United States is price inelastic (perhaps more inelastic than estimates at the retail level of the market might suggest). 0The income elasticity of demand is also very low. There is a negative and significant coefficient for the time trend suggesting that expenditure on coffee has been declining over the sample period 1962–1984.

The second stage of the demand model was estimated with and without symmetry for each model (AIDS and translog) and for each specification (with and without time). Symmetry could not be accepted for the translog model with or without time trend as an additional variable. However, it was accepted for the AIDS model. The quasi-convexity and monotonicity requirements of consumer theory (implying a negative semi-definite elasticity of substitution matrix and positive budget shares) are met for all observations for all specifications.

The exclusion of the time trend as an explanatory variable in the coffee models was rejected at the 1% level of significance (likelihood ratio test statis-

TABLE 4

Aggregate expenditure on coffee

Variable	Dependent variable: log of expenditure per caput on coffee		
	Coefficient	Elasticity	*T*-Statistics
Constant	7.306		5.39
Log of weighted average price	0.871	0.129	14.99
Log of disposable income	0.233	0.233	1.26
Time	−0.027		−6.98

$R^2 = 0.93$
$\overline{R}^2 = 0.93$
F-Statistic: 95.85
D.W. Statistic: 2.46

TABLE 5

Comparison of uncompensated price and expenditure elasticities, 1980 (estimated budget shares)

	Five types of coffee					EXP
	1	2	3	4	5	
AIDS model (time, symmetry and homogeneity imposed)						
1	−0.40	−0.70	0.48	0.22	−0.04	0.45
2	−1.66	−1.31	1.12	1.01	−0.14	0.98
3	0.54	0.99	−2.04	−1.08	0.11	1.48
4	−0.13	1.13	−1.68	−1.65	0.07	2.28
5	−0.16	−0.33	0.69	0.50	−0.73	0.02
Translog model (time, symmetry imposed, homogeneity maintained)						
1	−0.37	−0.74	0.48	0.25	−0.06	0.44
2	−1.72	−1.31	1.17	1.12	−0.15	0.90
3	0.58	1.05	−1.98	−1.21	0.13	1.44
4	−0.13	1.25	−1.95	−1.80	0.11	2.52
5	−0.28	−0.35	0.75	0.64	−0.78	0.04

tics 27.9 (translog) and 28.23 (AIDS)). This result suggests there have been changes in taste and preference patterns for consumers (processors) over the period of the analysis. The inclusion of time as an explanatory variable also reduced autocorrelation problems.

Given the improved statistical properties of the models including a time trend they are used for further analysis. Uncompensated price and expenditure elasticities for 1980 data for both models are reported in Table 5. Across the two

TABLE 6

Comparison of elasticities of substitution, 1980 (estimated budget shares)

	Five types of coffee				
	1	2	3	4	5
AIDS Model (Time, symmetry and homogeneity imposed)					
1	−0.54	−3.13	2.82	1.96	−0.36
2		−5.71	6.53	8.04	−1.64
3			−8.61	−6.07	3.45
4				−9.30	3.52
5					−13.55
Translog model (Time, symmetry imposed, homogeneity maintained)					
1	−0.47	−3.33	2.87	2.20	−0.67
2		−5.81	6.77	8.88	−1.76
3			−8.48	−7.25	3.79
4				−10.32	4.57
5					−14.05

TABLE 7

Price and expenditure elasticities (translog demand system)

	Five types of coffee					EXP
	1	2	3	4	5	
1965						
1	−0.13	−0.91	0.57	0.23	−0.06	0.30
2	−1.50	−1.28	1.03	0.98	−0.13	0.91
3	0.18	0.48	−1.42	−0.48	0.04	1.21
4	−0.11	1.07	−1.67	−1.69	0.09	2.31
5	−0.38	−1.06	2.16	1.52	−0.19	−2.04
1970						
1	−0.21	−0.85	0.54	0.23	−0.06	0.35
2	−1.83	−1.34	1.26	1.18	−0.15	0.89
3	0.26	0.59	−1.53	−0.62	0.06	1.25
4	−0.13	0.94	−1.46	−1.57	0.08	2.15
5	−0.30	−0.55	1.13	0.87	−0.62	−0.53
1975						
1	−0.22	−0.86	0.55	0.25	−0.06	0.35
2	−1.67	−1.31	1.14	1.09	−0.14	0.90
3	0.39	0.79	−1.72	−0.87	0.09	1.33
4	−0.14	1.00	−1.56	−1.61	0.08	2.23
5	−0.30	−0.48	0.99	0.79	−0.68	−0.23
1984						
1	−0.41	−0.70	0.46	0.24	−0.06	0.47
2	−2.42	−1.46	1.68	1.54	−0.19	0.85
3	0.49	0.93	−1.86	−1.05	0.11	1.39
4	−0.15	0.99	−1.54	−1.60	0.08	2.22
5	−0.28	−0.35	0.74	0.63	−0.78	0.04

models the demands for Colombian milds (2), unwashed arabicas (3) and robusta (4) coffees are price-elastic while the other two are price-inelastic. In both models, other milds (1) and Colombian milds, Indonesian robusta and Colombian milds, unwashed arabicas and robustas, and other milds and Indonesian robustas are found to be gross complements. All other relationships show substitutability rather than complementarity. From Table 6, it is clear that the same patterns of substitutability/complementarity are found in the elasticities of substitution suggesting that the different types of coffee are both gross *and* net substitutes or complements.

In both models the largest expenditure elasticity is for robusta coffees with unwashed arabicas and Colombian mild coffees following in that order.

Price and expenditure elasticities calculated from the translog model including a time trend variable are presented in Table 7 for a number of different observations. Major changes over time occur in the demand for Indonesian robusta coffees. These become much less price elastic and more expenditure elastic over the sample period. The demand for Colombian mild coffees become slightly more own and cross price elastic over time. Apart from these changes most price and expenditure elasticities remain unchanged over the sample period.

Implications

To examine the implications of the model for the United States as well as for exporters of different coffee types to the United States, the complete two-stage model was simulated under a number of different scenarios. It should be noted that since the supply functions for the various different coffee types were not estimated the model was simulated under the assumption of perfectly elastic supplies of all coffee types. Validation results from the base line simulation are reported in Table 8.

The results from the various simulations are not unduly surprising (see Table 9) given the estimated elasticities. For example, an increase in the price of other mild coffees (1) causes a decline in demand for other mild, Colombian milds and Indonesian robustas while demands for the other two coffees increase.

Exporters may face fluctuations in demand for their coffee due to exogeneous shocks to supplies of other coffee types. However, the results do not suggest that the coffee types are highly substitutable; rather the opposite is true in most cases. For an increase in aggregate expenditure on coffee the largest increases in demand are for robustas and unwashed arabicas while demand for Indonesian robustas decline.

The complementary and substitutability among the five types of coffee depend greatly on the blending recipes of roasters. The recipes change over time in response to tastes and relative prices.

The results show complementarity between 'other milds' and Colombian

TABLE 8

Validation statistics for base line simulation of two-stage coffee model

Variable	Mean	Correlation coefficient	Root-mean squared percentage error
Log of expenditure on coffee	9.52	0.97	6
Demand for other milds (1) (t)	390 956	0.75	11
Demand for Colombian milds (2) (t)	199 349	0.81	16
Demand for unwashed arabicas (3) (t)	342 399	0.93	15
Demand for robustas (4) (t)	221 764	0.86	17
Demand for Indonesian robusta (5) (t)	55 023	0.78	19

milds. This implies that the recipes for ground coffee in the United States require plain arabica (other milds) to be blended with higher quality and higher priced arabicas, i.e. the Colombian milds. The results also show complementarity between unwashed arabicas and robustas. This result is due to the fact that robustas and unwashed arabicas usually constitute the largest components of instant coffee.

Another interesting finding is the development over time of the expenditure and cross-price elasticities of Indonesian robusta coffee. The fact that cross-price elasticities become more inelastic and expenditure elasticities become larger (move from negative to positive) probably reflects the significant improvement in the quality of the coffee over time.

Methodologically the major finding of the study is the robustness of the empirical findings. Using different models to proxy consumer decision making (AIDS, translog) did not change the empirical results. In many empirical studies using one of the plethora of flexible functional forms, estimates of elasticities do vary with functional form. This is especially worrisome given the lack of complete information on the global properties of flexible functional forms. However, the robustness of the findings reported in this study suggests the responses captured accurately depict the coffee market in the United States.

The findings from this study are, in the main, consistent with a-priori expectations and have confirmed the fact that different types of coffee are not all substitutable, especially in the short run. In fact, because of inflexible recipes some coffees are complements rather than substitutes. This implies that a coffee exporting nation may not be able to increase its exports to the United States unless production and prices of other types of coffee complementary to

TABLE 9

Model simulation results (reported at means over sample period)

Variable	Base value	20% Increase in disposable income	%Δ	10% Increase in price of coffee 1	%Δ	10% Increase in price of coffee 2	%Δ	10% Increase in price of coffee 3	%Δ	10% Increase in price of coffee 4	%Δ	10% Increase in price of coffee 5	%Δ
Log of expenditure on coffee	9.52	9.87	+3.6	9.54	0.2	9.53	0.1	9.54	0.2	9.53	0.1	9.52	0
Demand for other milds (1)	390913	431 277	+10	385 276	−1	360 843	−7	414 457	6	42 045	3	389 230	−0.4
Demand for Colombian milds (2)	198179	271 033	+36	170 675	−14	176 512	−11	225 293	14	222 226	12	196 004	−1.1
Demand for unwashed arabicas (3)	340773	528 617	+55	361 290	+6	366 518	7	302 603	−11	324 283	−5	344 038	0.9
Demand for robustas (4)	222090	453 318	+104	232 309	+5	249 319	12	200 013	−10	196 462	−12	225 416	1.5
Demand for Indonesian robustas (5)	55220	37 217	−33	53 019	−4	52 077	−6	60 348	9	59 402	8	51 963	−6

its own type of coffee make them desirable for U.S. roasters. But, as we have seen in the case of Indonesian coffee, it is important to note that price and expenditure elasticities do change over time suggesting adjustment in roasting recipes in response to improved quality and price.

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