United States
Department of
Agriculture

Economic
Research
Service

**Agriculture and
Trade Analysis
Division**

Testing for the Impact of Inflation on Import Demand Functions

Carlos Arnade
Praveen Dixit

TESTING FOR THE IMPACT OF INFLATION ON IMPORT DEMAND FUNCTIONS by Carlos Arnade and Praveen Dixit, Agriculture and Trade Analysis Division, Economic Research Service, U.S. Department of Agriculture. Staff Report No. AGES 89-3.

ABSTRACT

This paper questions the standard assumption that inflation has no effect on import demand functions. We describe a simple method for testing whether proportionate changes in prices and income influence import demands. We estimate several import demand functions and provide some evidence that inflation influences importers' demand. We also show that, when estimating import demand functions, it is difficult to test for the correct index of inflation.

Keywords: Import demands, zero homogeneity, money illusion, elasticity

ACKNOWLEDGMENTS

We wish to thank Ron Babula, Dick Kennedy, Karen Liu, Michael Price, and Jerry Sharples for useful comments. Editorial assistance was provided by Tom McDonald.

1301 New York Avenue, NW.
Washington, DC 20005-4788

January 1989

CONTENTS

Testing for the Impact of Inflation on Import Demand Functions

Carlos Arnade and Praveen Dixit

INTRODUCTION

A well-established maxim of economics is that domestic demand curves are homogeneous of degree zero in income and prices. This implies, for example, that if prices and incomes are doubled, the demand for a product will not change. Zero homogeneous demand functions are derived from consumers who maximize utility subject to linear budget constraints. The common assumption that budget constraints are linear ensures that demand functions will be unaffected when income and prices change by an equal percentage.

This property of homogeneity in domestic demand functions is generally assumed in modeling international (excess) demand functions as well. Income and prices are specified in real terms with the Consumer Price Index (CPI) of the importing country typically being used as a deflator for prices. Yet, such an approach may be unwarranted in international trade modeling for several reasons: (1) purchasers may have imperfect knowledge about the current CPI of their country, (2) demand may be a function of wealth as well as of income, (3) trade rigidities may delay demand response to a price change, (4) the CPI may not be the appropriate index of goods to represent importers' purchases because it gives great weight to nontraded goods, and (5) zero homogeneity may not be preserved by aggregating domestic demand and supply functions.

If the homogeneity restriction is imposed when it is unwarranted, elasticity estimates may be inaccurate. This inaccuracy may convey false information to policymakers concerning the response of agricultural imports to both agricultural pricing and the general rate of inflation. While the role of agricultural prices in policymaking is apparent, the importance of inflation to the decisionmaking process is less evident.

Inflation establishes a link not only between the agricultural sector and the nonagricultural sector within a country but across countries. Policymakers may therefore be interested in the effects of relative inflation rates. If the price offered by exporters rises at the same rate as the buyers' CPI, imports will be unaffected when import demand functions are homogeneous of degree zero in prices and income. However, if import demand functions are not homogeneous of degree zero, imports may change even when the price offered by exporters rises at the same rates as the buyers' CPI.

Given the recent interest in the influences of macroeconomic policy on specific sectors of the economy, it is meaningful to address the influences of real and nominal prices on a country's imports. In this paper, we specify several import demand equations for agricultural products and test whether imposing zero homogeneity on these equations significantly reduces the equation fits. We also impose zero homogeneity on these equations and use this restriction to test for the correct index with which to deflate prices and income.

MONEY ILLUSION AND IMPORT DEMAND FUNCTIONS

Import demand equations in agricultural trade models are typically specified in real terms. Import prices in such models are usually deflated by the buyers' CPI to account for the absence of money illusion. While reviewing agricultural trade models built over the last three decades, Gardiner and Dixit found that nearly every study that used the direct estimation method to estimate import or export demand functions used real prices and incomes, thereby implicitly assuming the absence of money illusion (7).1/ Examples of studies that estimate import demand functions using real prices and income include Figueroa, Honma and Heady, and Wells and Johnson (5, 8, 13).

This leads one to ask why the property of homogeneity in income and prices is imposed while estimating import demand functions, and yet other properties of domestic demand functions (symmetry, for example) are not assumed.2/ Domestic demand functions are derived from utility-maximizing consumers who are assumed to have perfect knowledge and do not influence prices. Domestic supply functions are derived from profit-maximizing producers who are assumed to have perfect knowledge and do not influence prices. Since imports are often depicted as the difference between demand and supply functions, it seems reasonable to assume that the zero homogeneity property carries over to import demand functions.

Yet, import demand functions present several difficulties. For example, macroeconomists have over the years argued that leisure demand functions may not be homogeneous of degree zero when consumers have imperfect knowledge of prices (10). Lucas emphasized that agents can be fooled into believing that movements in nominal prices are real price movements.3/ He showed that nominal wage increases can temporarily fool consumers into demanding less leisure even under rational expectations. We believe that this same argument can be extended to demand for other goods, including goods traded across international borders. If consumers within a country cannot distinguish between nominal and real wages, it is very plausible that foreign buyers are also unable to distinguish between nominal and real prices of a product. This could be particularly true when exchange rates, which have been volatile throughout the 1970's, influence the price that the buyers face.

If importers do not know the real price of the goods they import, then the nominal price of these goods may better explain the behavior of importers than the real price of these goods.

1/ Underscored numbers in parentheses refer to sources cited in the References.

2/ To impose symmetry, one must estimate a system of of nonsimultaneous equations and impose cross equation restrictions. This is often done for estimating domestic demand equations. Yet, international equations are either estimated from a system of simultaneous equations or as a single equation (7).

3/ Lucas was interested in labor supply curves that can be easily obtained from leisure demand curves (10).

DERIVING IMPORT DEMAND FUNCTIONS

Several viewpoints suggest how to derive an import demand equation. Since contrasting the methods of specifying an import demand function is not the focus of this paper, we follow the most commonly held viewpoint and assume that an excess demand function is equivalent to an import demand function. Other methods of specifying import demand functions exist, yet we want to test the homogeneity restriction on the most commonly used specification. To illustrate the relationship between zero homogeneity and import demand functions, we begin with a typical derivation of a domestic demand function and then establish conditions to obtain an excess demand or import demand function.

A Marshallian domestic demand function can be derived by representing agents as maximizing utility with respect to income or:

$$\text{Max}_x \; U(x_i) \text{ subject to: } \Sigma p_i x_i = Y$$

where U(.) is a utility function written as a function of a vector of goods x_i, and $\Sigma p_i x_i = Y$ is a linear budget constraint written as a function of nominal domestic prices p_i, and nominal income, Y. The individual's domestic demand functions, that is, good one, can be written as:

$$X_1 \, (p_1, p_2 \cdots p_n, Y) \qquad (1)$$

where p_n is the nth good. Deaton and Muellbauer (3) show that under certain conditions the prices of many goods in equation 1 can be replaced by a single price index. For example, the prices of goods one and two can be written out, while the remaining prices can be lumped together into an index. We follow this approach and lump prices p_3 to p_n into an index which we call the CPI.

Equation 1 is commonly viewed as being a homogeneous of degree zero demand function. Therefore, it is common practice in estimating domestic demand equations to normalize on the CPI index and write domestic demand in real variables as:

$$X_1 \, (p_1/CPI, \, p_2/CPI, \, \ldots\ldots \; Y/CPI) \qquad (2)$$

Alternately, the demand function can be normalized on a substitute or complement price. This could be written as:

$$X_1 \, (p_1/p_2 \, \ldots \, CPI/p_2, \, Y/p_2) \qquad (3)$$

Having obtained the Marshallian demand functions, imports are now defined as the excess of domestic demand over supply. We can write an import demand for a good using real variables as:

$$IM = X_1(p_1/CPI, \, p_2/CPI, \, Y/CPI) - S_1(p_1/CPI \ldots w_i/CPI) \qquad (4)$$

where IM is imports of a good, S_1 is supplies of the good, and w_i represents the ith input price. These supply functions are derived from profit-maximizing producers and also are assumed to be homogenous of degree zero. Economists often assume that supplies are fixed in the short run so that the supply function in equation 4 can be replaced by a fixed level of supplies. In either case, equation 4 is homogenous of degree zero in prices and income.

Changing all prices and income by an equal percentage does not alter the level of imports.4/

Though theory says equation 4 is homogeneous of degree zero, there are several practical reasons why homogeneity may appear to be violated when an econometric model of equation 4 is estimated.

First, purchasers may have imperfect knowledge about the current CPI of their country. This is essentially the line of argument Lucas uses for domestic demand curves. The CPI is often reported at the end of a quarter. Unless all purchases are made at the end of a quarter, consumers and producers probably do not know the current value of the CPI. Suppose the CPI term in equation 4 followed a random walk or that:

$$CPI = CPI_{t-1} + U, \qquad (5)$$

where U is an error term whose expectation is zero. Then

$$E(CPI) = CPI_{t-1} \qquad (6)$$

where E(.) refers to expectations, and $_{t-1}$ refers to the previous period.

Since consumers and producers must act on the expected price, equation 4 must be written as:

$$IM = X_1(p_1/CPI_{t-1}...) - S_1(.....w_i/CPI_{t-1})$$

$$= X_1(p_1/CPI-U\ .....) - S_1(.....w_i/CPI\ -U) \qquad (7)$$

A doubling of prices and income does not leave demand unaltered because:

$$(p_1/CPI - U) \neq (2p_1/2(CPI) - U) \qquad (8)$$

This problem can be avoided by replacing the CPI by a lagged CPI as in equation 7. Expectations, however, rarely follow such a simple form. To find the correct data that represent the expected CPI may be difficult. Lucas shows how homogeneity may be violated even when consumers are rational and take into account information on current price in deriving their forecasts of the CPI.

Second, demand may be a function of wealth as well as of income. The wealth of consumers can be represented by the value of their assets. Changes in nominal prices can influence the value of consumer assets and thus shift the demand curve.

Third, trade rigidities may delay demand response to a price change. If consumers respond to lagged prices, then prices are not the correct argument

---

4/ Economists seem to differ on the correct specification for import demand functions. Homogeneity tests can be applied to their own import demand functions. For certain countries and certain products, tariffs and other policy variables can be included in equation 4. However, the addition of these variables takes the import demand function further away from the homogeneous of degree zero domestic demand function. Since we are interested in testing for zero homogeneity in import functions, we refrain from formulations that make this likelihood less possible.

in equation 4. A proof analogous to that used in equations 7 and 8 will show that specifying import demand equations with prices rather than lagged prices can lead to a violation of the zero homogeneity condition.

Fourth, the CPI may not be the appropriate index of goods to represent importers' purchases because it gives great weight to domestic goods. Suppose domestically produced goods were separable from traded goods. The CPI term in equation 4 should be replaced by some index representing the price of traded goods. Such an index is often not available and may not rise in proportion to a country's CPI. Import demand functions specified with the CPI would not be homogeneous of degree zero. Even if domestic goods were not separable, a correct index should be composed of a weighted average of the CPI and an index of prices of traded goods.

Fifth, zero homogeneity may not be preserved by aggregating domestic demand and supply functions. Homogeneity will hold only if incomes for each individual are increased in the same proportion as price (see Appendix A).

DESCRIBING THE TEST

To test the hypothesis of the presence of money illusion in import demand functions, we tested to see if the sum of price and income elasticities is zero in a log-linear import demand function. This homogeneity test can be done for a specification that includes or excludes the CPI of the buying country. Euler's theorem is often used to prove that the sum of price of income elasticities of a demand or supply function equals the degree of homogeneity (12). A less general but simple illustration of this restriction can be shown by writing a log linear domestic import demand function as:5/

$$Ln(IM) = b_o + b_1*Ln(Y_M/CPI) + b_2*Ln(p_1/CPI) + b_3*Ln(p_2/CPI) + b_4*Ln(S) \quad (9)$$

By summing terms, equation 9 can also be written as

$$Ln(Im) = b_o + b_1*Ln(Y) + b_2*Ln(p_1) + b_3*Ln(p_2) + b_4*Ln(S) - (b_1 + b_2 + b_3)*Ln(CPI) \quad (10)$$

When estimating equation 10, it is possible to restrict its parameters so that the equation model behaves as if real variables have been used. Let the

---

5/ Imports are described as domestic demand minus supply. The derivative of imports with respect to domestic supply equals -1. This reflects unit-for-unit substitution of domestic imports for domestic supplies. The coefficient on the supply term in equation 9 represents the elasticity of imports with respect to supply (or $\partial Log(IM)/\partial Log(S) = (\partial IM/\partial S)*(S/M)$), which cannot equal -1. Therefore, the coefficient on the domestic supply term must be estimated. Under free trade, the price buyers face is the domestic currency equivalent of the seller's price. The excess demand function can be written as:

$$IM = b_o + b_1*(Y/CPIM) + b_2*(P_{s1}/CPIS)*E*(CPIS/CPIM) + b_3*(P_{s2}/CPIM)*E*(CPIS/CPIM) + b_4*S$$

where Y is income in the importer's currency, CPIM is the buyer's CPI, CPIS the seller's CPI, E the price of the dollar in the importer's currency, and P_{s1} the seller's price of the product in dollars (or exporter's currency).

coefficient on CPI be called a_1. Estimating equation 10 and testing whether the group of estimators

$$\hat{a}_1 = -(\hat{b}_1 + \hat{b}_2 + \hat{b}_3)$$

is equivalent to testing whether the sum the price and income elasticities equals zero. This represents our <u>first</u> test for money illusion where CPI is included in the equation.

If the import good is an input, normalization on the wholesale price index may be more appropriate. In other cases, prices of a substitute or complementary good may be deemed more appropriate. Suppose the CPI was dropped from equation 10, and the equation written as:

$$Ln(Im) = b_o + b_1{*}Ln(Y) + b_2{*}Ln(p_1) + b_3{*}Ln(p_2) + b_4{*}LnS \qquad (11)$$

Estimating equation 11 and testing whether the group of estimators

$$\hat{b}_1 + \hat{b}_2 + \hat{b}_3 = 0$$

is equivalent to testing whether the import demand function in equation 11 is homogeneous of degree zero. If the restriction holds, it is equivalent to specifying an import demand function without the CPI and normalizing on the price and income variables on price of a substitute or complementary good.

EMPIRICAL RESULTS

Economists have theorized that people who reside in economies that have experienced inflation in the past are unlikely to confuse nominal and real price signals later. Similarly, customers in inflation-prone countries are less likely to be misled by nominal prices. We estimated wheat and soybean import demand equations for countries with diverse inflation rates. We chose five countries: Brazil, Mexico, Spain, Japan, and Taiwan. The annual rates of inflation in these five countries in 1985 were 226 percent, 58 percent, 9 percent, 2 percent, and 1 percent.

Import demand equations for wheat and soybeans for these five countries were estimated using ordinary least squares (OLS) regression with data covering the late 1960's to the early 1980's. The time period is not uniform across countries because data availability varied from country to country. The import variable represents the total amount the country of interest imported and was obtained from official USDA data. Price data were obtained from USDA's <u>Foreign Agricultural Trade of the United States</u>. Data on nominal exchange rate, consumer price indices, and the gross national products were obtained from the International Monetary Fund's <u>International Financial Statistics</u>.

The specifications of the import demand functions are meant to reflect typical models of these countries. We estimated each equation twice, once with the homogeneity restrictions and once without the homogeneity restrictions. Our null hypothesis was that the homogeneity restriction does not significantly reduce equation fit. To test our null hypothesis, we used an F test which follows standard procedure for determining if restrictions on estimators reduce equation fit (<u>2</u>). A high F indicates the "homogeneity restrictions" significantly reduce the fit of an equation. For example, if the estimated F is greater than its table value at the 0.1 confidence level, we can reject the null hypothesis with 90-percent confidence.

Tables 1-7 report our equations estimated for soybean and wheat across five countries. The equations were estimated in double-log form so the reported parameters represent elasticity estimates. Each table reports relevant fit statistics and the F statistics for the homogeneity tests of interest.

Each country equation was specified twice, once with the CPI and once without it. The F statistics for the equations that included the CPI in the specification varied. They were low and insignificant in the soybean equations but high enough to be significant in two of the three wheat equations. In contrast, the F statistics for all the equations that excluded the CPI were significant.6/ These results are revealing. Import demand

6/ The usefulness of this F statistic is questionable in equations with only one price, such as the wheat equations.

Table 1--Soybean imports, Spain, 1970-85

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	0.47 (-2.05)	0.15 (-2.46)	1.76 (2.05)	5.09 (3.15)
GNP	1.55 (3.01)	.87 (5.71)	.79 (.21)	5.14 (.99)
Price of soybeans	-.25 (-.20)	-1.06 (-.87)	-.28 (-.07)	-1.24 (-.58)
Price of soymeal	-.09 (-.09)	-.41 (-.43)	-.09 (-.15)	-.43 (-.37)
Soybean production	.005 (-.048)	(.026) (-.273)	.04 (.51)	.25 (1.94)
CPI	-.91 (-2.72)	-.42 (-5.44)	NA	NA
Rbar sq	.72 (.74)	NA	.74 (.09)	NA
Dw	2.07 (1.87)	NA	2.13 (1.32)	NA

F for restriction 2/ (1,11) = .75 F for restriction (1,12) = 31.89

NA = Not available. 1/ The estimators and T statistics for the unrestricted model are above the numbers in parentheses. The estimators and T statistics for the restricted models are in parentheses. 2/ The first F statistic reflects the test that an unrestricted model is significantly different from one that has parameter restrictions which impose zero homogeneity. A low F reflects there is no significant difference and the true model is one that is homogeneous of degree zero. This format holds throughout the tables.

equations that exclude the CPI in their specification have significantly poorer fits after imposing zero homogeneity. It is, therefore, questionable whether modelers should exclude the CPI from their import demand equations and normalize import demand equations on a competing price.

Standard statistical tests cannot be used to determine if the elasticities of a real equation are significantly different from the elasticities in a nominal equation.7/ However, informally comparing elasticities may provide some interesting answers.

The income elasticities in the soybean equations for Spain, Japan, and Mexico change significantly from the real to the nominal equation. The income elasticities for the import demand equations specified in real terms tend to be much higher. Price elasticities change less. In the Brazilian wheat equation, however, the price elasticity is the right sign in the nominal equation but changes to the wrong sign in the real equation. These results

7/ A real demand equation is not nested within a nominal demand equation. Nesting is discussed in Appendix B. The unrestricted models (nonbracketed) on the right side of the tables without the CPI are nominal import demand functions. The restricted models (bracketed) on the left hand side of the tables are real import demand functions.

Table 2--Soybean imports: Mexico, 1970-83

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	-3.95 (-4.96)	-2.25 (-4.88)	-1.55 (-1.90)	-1.43 (-.62)
GNP	3.69 (4.90)	1.99 (6.85)	.68 (-1.01)	1.57 (-.92)
Price of soybeans	-2.73 (-2.57)	-2.40 (-2.37)	-3.10 (-2.51)	-2.53 (-.73)
Price of soymeal	3.51 (3.39)	3.31 (3.33)	3.79 (3.53)	3.31 (1.10)
Soybean production	-.25 (-.32)	-.56 (-.73)	-.017 (1.79)	-.036 (1.53)
CPI	-4.40 (-5.71)	-1.66 (-9.45)	NA	NA
Rbar sq	.90 (.87)	NA	.88 (.11)	NA
Dw	1.83 (1.74)	NA	1.79 (1.16)	NA

F for restriction (1,9) = .508 F for restriction (1,10) = 68.2

1/ See table 1 for note and footnotes.

are important because they indicate a lack of robustness as models go from being specified in nominal to being specified in real terms.

TESTING FOR THE CORRECT INDEX

Related to the homogeneity issue is the issue of which index is the most appropriate to use as a deflator in a demand equation. This problem concerning the choice of a price index becomes especially critical with import demand functions. Should modelers deflate by the CPI, the wholesale price indices, indices of the prices of traded goods, or the indices of the prices of domestic goods (6).8/ Formal testing of the appropriate index in an import demand function is rarely done.

8/ This is particularly true when import demand equations are written explicitly as a function of real exchange rates (see footnote 3). The correct price indices to define the real exchange rate is itself the subject of controversy.

Table 3--Soybean imports, Japan, 1970-85

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	1.67 (1.26)	2.06 (3.46)	2.58 (.30)	12.25 (8.51)
GNP	.64 (.82)	1.91 (6.25)	.28 (.30)	6.54 (3.86)
Price of soybeans	-.05 (-.021)	-.45 (-.24)	-.036 (.14)	-.21 (1.07)
Price of soymeal	.02 (.006)	.33 (.10)(-.11)	.015 (-1.28)	.14
Price of rapeseeds	-.09 (-.11)	-1.00 (-1.26)	-.05 (-.33)	-.69 (-3.02)
Soybean production	-.083 (-1.08)	-.87 (-1.35)	-.01 (.057)	-.12 (.51)
CPI	-.452 (-.70)	-.98 (-4.24)	NA	NA
Rbar sq	.89 (.90)	NA	.89 (.75)	NA
Dw	2.04 (2.10)	NA	1.85 (1.24)	NA

F for restriction (1,10) = .33 F for restriction (1,11) = 16.25

1/ See table 1 for note and footnotes.

In this section, we test to examine if the CPI should be included as a normalizing variable in an import demand function that is a priori restricted to be homogeneous of degree zero in income and prices. This test will tell us whether some other price variable (for example, a substitute price) is preferable to the CPI for deflating prices and income when the homogeneity restriction holds. For example, we impose zero homogeneity and examine if the CPI should be included in a homogeneous of degree zero import demand function. In this case, we estimate equation 10 with the restriction:

$$a_1 = -(b_1 + b_2 + b_3)$$

and test this against the two restrictions:

$$a_1 = -(b_1 + b_2 + b_3)$$

$$a_1 = 0 = -(b_1 + b_2 + b_3).$$

Note this second test is only possible since the latter restriction ($a_1 = 0 = -(b_1 + b_2 + b_3)$) is contained within or nested within the first restriction ($a_1 = -(b_1 + b_2 + b_3)$).

Table 4--Soybean imports, Taiwan, 1970-85

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	0.93 (.83)	1.00 (.92)	1.06 (2.85)	1.38 (6.91)
GNP	.47 (.60)	1.73 (3.07)	.40 (.20)	3.09 (1.56)
Price of soybeans	.14 (.23)	.55 (.99)	.11 (.17)	.49 (.63)
Price of soymeal	-.26 (-.34)	-1.27 (-1.92)	-.24 (-.37)	-1.33 (-1.78)
Soybean production	-.05 (-.10)	-.35 (-.89)	-.036 (-.265)	-.289 (-2.36)
CPI	-.15 (-.50)	-.28 (-2.45)	NA	NA
Rbar sq	.87 (.88)	NA	.88 (.83)	NA
Dw	2.57 (2.70)	NA	2.45 (1.63)	NA
F for restriction (1,11) = .49			F for restriction (1,12) = 6.72	

1/ See table 1 for note and footnotes.

Table 8 contains statistics that we call F. These F statistics represent a test of the import equation with the CPI against the equation without the CPI. Both of these equations are restricted *a priori* to be "homogeneous of degree zero." In other words, we are interested in testing to see if:

$$Ln(Im) = b_0 + b_1*Ln(Y) + b_2*Ln(p_1) + b_3*Ln(p_2) + b_4*Ln(S) - (b_1 + b_2 + b_3)*Ln(CPI) \quad (12)$$

has a significantly different fit from:

$$Ln(Im) = b_0 + b_1*Ln(Y) + b_2*Ln(p_1) - (b_1 + b_2)*Ln(p_2) + b_3*Ln(SI) \quad (13)$$

The null hypothesis is that equation 12 does not provide a significantly better fit than equation 13. A high F statistic indicates that we can reject this null hypothesis.

Table 8 reports the F statistics. The F statistics that test for inclusion vis-a-vis exclusion of the CPI when "homogeneity of degree zero" is imposed are significant at the 1- or 5-percent level. With 95-percent confidence, we can reject the null hypothesis in all equations but the Spanish wheat equation. Therefore, if homogeneity of degree zero is imposed on import demand functions, modelers should at least include the CPI in their model. It seems reasonable to assume that modelers who include the CPI in the model are most likely to use it as a deflator rather than keeping the CPI in the model and deflating prices and income by the price of a substitute or complement good.

Table 5--Wheat imports, Brazil, 1970-84

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	3.41 (3.04)	7.06 (5.33)	3.26 (3.01)	7.26 (4.75)
GNP	.31 (.51)	1.74 (2.55)	.43 (-.08)	3.70 (-2.85)
Price of wheat	-.23 (.11)	-1.73 (4.64)	-.12 (.08)	-2.49 (2.85)
Wheat production	-.23 (-.18)	- 1.57 (-.98)	-.23 (.03)	-1.60 (.13)
CPI	.38 (-.62)	.90 (-2.98)	NA	NA
Rbar sq	.72 (.58)	NA	.73 (.31)	NA
Dw	2.01 (1.55)	NA	1.86 (1.30)	NA
F for restriction (1,9) = 6.73			F for restriction (1,10) = 19.88	

1/ See table 1 for note and footnotes.

CONCLUSION

Theory tells economists that domestic demand and domestic supply functions are homogeneous of degree zero. Therefore, import demand functions, which represent the difference between domestic demand and supply functions, are homogeneous of degree zero. Yet, theory applies to individual agents who have perfect knowledge of prices. When economists estimate their demand functions, they are faced with real world problems concerning aggregation and obtaining data that represent the price signals that agents respond to. Because of this, the zero homogeneity restriction may distort the true nature of the relationships between the quantity imported and price and income data available to the economist. This has implications for policymakers. If modelers make incorrect assumptions considering imposition of money illusion, elasticity estimates may be inaccurate.

Our results indicate that if zero homogeneity is imposed on import demand functions, the CPI index should be included in the model, either as a deflator or as an exogenous variable. We expect most modelers will choose to use it as a deflator. Other indices such as the trade price index or the wholesale price index have not been tested. We also do not know if our results would be robust across different specifications of import demand functions. In the future, it would be of interest to use other indices to test for zero homogeneity in import demand equations.

Table 6--Wheat imports, Mexico, 1970-83

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	11.04	1.31	25.91	2.46
	(18.77)	(2.63)	(2.83)	.24
GNP	14.81	2.84	.75	.45
	(9.74)	(3.49)	(-3.72)	(-2.46)
Price of wheat	1.59	1.70	1.82	1.51
	(1.52)	(1.60)	(3.72)	(2.46)
Wheat production	-8.76	- 3.07	-9.27	-2.51
	(-9.77)	(-3.55)	(.27)	(.07)
CPI	-18.39	-2.79	NA	NA
	(-11.26)	(-5.07)		
Rbar sq	.77	NA	.62	NA
	(.57)		(.24)	
Dw	1.96	NA	1.19	NA
	(1.16)		(.86)	
F for restriction (1,9) = 9.07			F for restriction (1,10) = 11.96	

1/ See table 1 for note and footnotes.

In sum, we have raised an issue and provided international trade modelers with a simple method to investigate it. Given the importance of this possible direct link of macroeconomic policy to agriculture, we suggest that it would be useful for modelers to test for the appropriate normalizing variable. Whether the results produced in this paper hold up after further testing and under different specifications is an issue that may invite future research.

Table 7--Wheat imports, Spain, 1970-85

Item	Models with CPI 1/		Models without CPI	
	Coefficients	T statistics	Coefficients	T statistics
Constant	0.74 (14.47)	0.08 (3.96)	14.24 (14.79)	3.90 (3.94)
GNP	8.41 (.69)	1.85 (1.33)	.84 (.004)	1.36 (.04)
Price of wheat	-.65 (-.55)	-1.65 (-1.30)	-.56 (-.004)	-1.33 (-.044)
Wheat production	-3.23 (-3.23)	-3.41 (-3.27)	-3.34 (-3.22)	-3.29 (-3.09)
CPI	-8.79 (-.14)	-1.67 (-1.05)	NA	NA
Rbar sq	.46 (.38)	NA	.38 (.34)	NA
Dw	1.76 (1.29)	NA	1.31 (1.13)	NA
F for restriction (1,11) = 2.91			F for restriction (1,12) = 5.07	

1/ See table 1 for note and footnotes.

Table 8--Testing for the correct index when zero homogeneity is imposed

Soybeans, country	F	Confidence level	Wheat, country	F	Confidence level
Spain	142.0	1%	Brazil	11.6	1%
Mexico	9.5	5%	Spain	1.3	NS
Japan	242.0	1%	Mexico	36.0	1%
Taiwan	7.9	5%			

NS = Not significant.

REFERENCES

(1) Aradhyula, S., and T. Kesavan. "Discriminating Alternative Meat Demand Systems Using Non-Nested Tests." Paper presented at the annual meetings of the 1987 Western Agricultural Economics Association, Manhattan, KS.

(2) Chow, G. Econometrics. New York: McGraw-Hill, 1983.

(3) Deaton, A., and J. Muellbauer. Economics and Consumer Behavior. Cambridge University Press, Cambridge, England, 1980.

(4) Economic Research Service, U.S. Department of Agriculture. Foreign Agricultural Trade of the United States, various issues.

(5) Figueroa, E.E. "Implications of Changes in the U.S. Exchange Rate For Commodity Trade Patterns and Composition." Ph.D. dissertation, University of California, Davis, 1986.

6) Frenkel, Jacob. "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," in Frenkel and Johnson, ed., The Economics of Exchange Rates. Reading, MA: Addison-Wesley, 1978.

(7) Gardiner, W., and P. Dixit. "Price Elasticity of Export Demand for U.S. Agricultural Products: Methods and Estimates." Paper presented at the Southern Agricultural Economics Association meetings, Feb. 1-4, 1987, Nashville, TN.

(8) Honma, M., and E.O. Heady. An Econometric Model for International Wheat Trade: Exports, Imports, and Trade Flows. CARD Report 124. Center for Agricultural and Rural Development, Ames, IA, 1984.

(9) International Monetary Fund. International Financial Statistics, various issues, Washington, DC.

(10) Lucas, Robert E., Jr. "Expectations and Neutrality of Money," Journal of Economic Theory, 1972, pp. 103-24.

(11) Sheffrin, Steven. Rational Expectations. Cambridge University Press, Cambridge, England, 1983.

(12) Varian, Hal R. Microeconomic Analysis. New York: W.W. Norton and Co., 1978, Chs. 1, 2.

(13) Wells, G.J., and P.R. Johnson. "The Impact of Entry into the European Community on the Pattern of the United Kingdom Wheat Imports: Projections to 1980." North Central Journal of Agricultural Economics, Vol 2, 1980, pp. 83-94.

APPENDIX A

Aggregating demand functions may lead to a violation of the zero homogeneity restrictions. Below is a simple illustration of why zero homogeneity may be violated when consumer incomes do not change by equal amounts.1/

Write the domestic demand as:

$$X_1(p_1/CPI \,..Y_1/CPI_1) \qquad (1a)$$

Suppose there are two consumers. Demand by consumer 1 is:

$$X_{11}(p_1/CPI...Y_1/CPI) \qquad (2a)$$

where Y_1 is the first consumer's income.

Demand for consumer 2 is:

$$X_{21}(p_1/CPI...Y_2/CPI) \qquad (3a)$$

where Y_2 refers to the second consumer's income,

$$X_{11} + X_{21} = X_1$$

and $Y_1 + Y_2 = Y$

Suppose the price is doubled, and income of individual 2 increases by Y. Then the price to consumer 1 has doubled but his income is the same, so:

$$X_{11}(2p_1/2CPI...Y_1/2CPI) \neq X_{11}(p_1/CPI...Y_1/CPI) \qquad (4a)$$

The price to consumer 2 has doubled, too, but his income has more than doubled, so:

$$X_{21}(2p_1/2CPI...Y_1 + Y/2CPI) \neq X_{21}(p_1/CPI...Y_1/CPI) \qquad (5a)$$

By adding two inequalities together, one concludes that:

$$X_1(2P/2CPI,\ 2Y/2CPI) \neq X_1(P/CPI,\ Y/CPI)$$

APPENDIX B

It is incorrect with standard testing procedures (such as the F test) to test an equation specified with real prices and real income against an equation specified in nominal prices and nominal income. To see this test, we write equation 10 as:

$$Ln(Im) = b_o + b_1{*}Ln(Y) + b_2{*}Ln(p_1) + b_3{*}Ln(p_2) + b_4{*}Ln(S) - (a_1){*}Ln(CPI) \qquad (1b)$$

Models specified in real prices and real incomes are equivalent to imposing the restriction:

$$a_1 = -(b_1 + b_2 + b_3)$$

1/ We are grateful to Michael Price for providing us with this illustration.

Models specified in nominal prices and nominal income are equivalent to imposing the restriction:

$a_1 = 0.$

Standard hypothesis tests cannot be used to test an equation with <u>only</u> the restriction that the coefficient: $a_1 = 0$ against an equation with the restriction that the coefficient: $a_1 = -(b_1 + b_2 + b_3)$. The flaw in this case is that neither restriction is nested within the other. Modelers cannot obtain a real (nominal) demand function by imposing one restriction upon a nominal (real) demand function. To further clarify these points, examine figure 1.

Figure 1: Alternative Tests For Money Illusion

ZERO HOMOGENEITY RESTRICTION HOLDS	ZERO HOMOGENEITY RESTRICTION DOES NOT HOLD
I. CPI IN EQUATION $b_1 + b_2 + b_3 = a_1$	II. CPI IN EQUATION b_1, b_2, b_3, a_1
III. CPI NOT IN EQUATION $b_1 + b_2 + b_3 = a_1 = 0$	IV. CPI NOT IN EQUATION $b_1, b_2, b_3,$ but $a_1 = 0$

Each quadrant in figure 1 represents the restrictions imposed on the estimators of an econometric model. The coefficient restriction in quadrant I is equivalent to specifying an import demand equation in real terms. The lack of coefficient restrictions in quadrant II is equivalent to specifying an nominal import demand function and including the CPI as an additional variable. The coefficient restrictions in quadrant III specify an import demand equation in real terms, not including the CPI, and normalizing on a competing price. The coefficient restriction in quadrant IV is equivalent to specifying an import demand equation in nominal terms.

By moving both vertically and horizontally in figure 1, one can obtain nested restrictions. Along the vertical, the restriction on the estimators in quadrant III is a special case of the restriction on the estimators in quadrant I. Also, the restriction on the estimator in quadrant IV are a special case of quadrant II which represents an unrestricted equation. Along the horizontal, the restriction in quadrant I is a special case of the unrestricted model in quadrant II. Similarly, the restrictions in quadrant III are a special case of the restriction in quadrant IV. However, one cannot move diagonally from quadrant I to quadrant IV and obtained nested restrictions.

Quadrant I represents the typical specification of a demand function written in real terms, and quadrant IV represents the typical specification of an import demand function written in nominal terms. Modelers must use methods of testing non-nested equations to discriminate between quadrant I and quadrant IV (<u>1</u>). Yet such tests are not widely accepted and may prove time consuming. Another approach is to avoid formal comparison of a nominal import demand equation with a real import demand equation.

We have chosen to use this second approach. In earlier parts of this paper, we twice tested for zero homogeneity in import equations. The first test was executed in equations with the CPI and represents testing the specification in quadrant I against the specification in quadrant II. The second test was executed in equations without the CPI and represents testing the specification in quadrant III against the specification in quadrant IV.

In the second part of the paper, we <u>impose</u> zero homogeneity and test whether the CPI's should be included in the specification. This represents testing quadrant III against quadrant I.

☆U.S. Government Printing Office : 1988 - 241-793/80352