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An econometric analysis of U.S. vital wheat gluten imports

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ABSTRACT

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In light of the wheat wet milling industry's development in the E.C. and of the prominent role U.S imports play in the international market for wheat gluten, this paper discusses the international market for wheat gluten, an important component of processed grain products. An econometric analysis of the U.S. import demand for wheat gluten is undertaken. The price of flour, income, and the U.S. value of wheat protein are found to be important determinants of wheat gluten imports.

Traditional theories of international trade maintain that countries will specialize in Producing and exporting those commodities for which they hold a comparative production advantage. However, an examination of actual trade flows often reveals the simultaneous import and export of a product by a particular country. For example, in 1988, the U.S. exported over 14 billion dollars worth of grain products but also imported over 909 million dollars worth of grains (U.S. Department of Agriculture, 1989). Such intraindustry trade is usually attributable to product differentiation, which is often obscured through the use of aggregate commodity definitions.

An important, but little-recognized, example of intraindustry trade involves the international market for wheat gluten. The U.S. is one of the

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billion (US) = 10^9.

major wheat producers and exporters in the world. Furthermore, a great amount of the U.S. wheat production and trade is of hard wheat which yields high-protein flour. However, in 1988, the U.S. imported over 35 thousand metric tonnes of wheat gluten for use primarily as a protein enhancer for wheat flour. The reasons for the U.S.'s position as a net importer of wheat gluten are complex, but principally follow from the fact that exports of gluten from Australia, Canada, the E.C. and other smaller producing countries are available at a cost that is competitive to that of domestically produced gluten.

The relative abundance of wheat gluten in the rest of the world can be traced to the fact that wheat gluten is produced jointly with wheat starch. [1] Commercial uses for gluten are somewhat limited relative to those for starch, which is an important input into processed food manufacturing (Pomeranz, 1988). The majority of the leading wheat producing countries do not possess a large corn base, another important source of starch for food and commercial uses. In contrast, the U.S. enjoys a relatively abundant supply of starch from its large corn base. [2] In addition, agricultural policies in trading countries are partially responsible for the existence of a large international market in wheat gluten. Highly subsidized production of wheat in the E.C. has led to large domestic surpluses of wheat products in recent years.

The E.C. has realized considerable investments in the wheat wet milling industry over the past few years. This high level of investment has led E.C. producers to turn to the export market. This capacity of production is now higher than the quantity exchanged on the international market. With almost no exports until 1983, the E.C. ranked second in exports bound for the U.S. in 1988, holding approximately 17.5% of the U.S. import market share.

In light of the wheat wet milling industry's development in the E.C. and of the prominent role U.S. imports play in the international market for wheat gluten, it is of interest to empirically examine factors that are related to the demand for imported wheat gluten in the U.S. The objectives of this paper are twofold. First, the structure and mechanics of the wheat gluten industry [3] and the international wheat gluten market are examined. Second, a detailed econometric analysis of the U.S. demand for imported wheat gluten is undertaken. The paper proceeds according to the following plan. The next section briefly describes the international wheat gluten industry. The following section empirically examines factors that affect the

[1,2,3] Endnotes on pp. 73–74.

U.S. demand for imported wheat gluten. The final section contains a brief review of the analysis and offers some concluding remarks.

INTERNATIONAL WHEAT GLUTEN INDUSTRY

Wheat gluten is the water insoluble protein fraction of wheat flour. Commercial wheat gluten is obtained by separation from starch through the wet-milling process. It is marketed as a free-flowing powder, which is obtained by careful drying. In spite of a relatively low nutritional quality, wheat gluten is a unique vegetable protein of considerable commercial value. [4] Viscoelasticity, thermosetting ability and water absorption are its most valuable properties. Wheat gluten is mostly utilized in the milling and baking sector (approximately 75 percent of wheat gluten end-usages), where gluten is a protein complement in flour and other wheat products [5] (IWGA, 1989). Powdered wheat gluten rapidly absorbs approximately twice its weight of water, which restores its intrinsic functionality. The combination of speed of water absorption and ability to form a viscoelastic mass when fully hydrated leads to the commonly used designation "vital wheat gluten" (IWGA, 1989). Its unique properties position wheat gluten apart from other protein sources. This results in the lack of any substitute for vital wheat gluten.

The wheat gluten industry consists of 43 companies located throughout 19 countries. Out of these 43 companies, 35 are located in four main areas: Australia (4), Canada (1), the E.C. (26), and the US (4). The international market represents a little more than one fourth of total production. In 1988, approximately 60 000 tons of vital wheat gluten was traded between countries (IWGA, 1989). Surpluses in Canada, Australia, and the E.C. have given rise to exports. The U.S. is the world's largest importer of wheat gluten, accounting for 60% of total world imports (IWGA, 1989).

The evolution of wheat gluten imports by the United States is illustrated in Fig. 1. The figure displays a general upward trend in the quantity of wheat gluten imported since 1974. However, after a sharp increase from 1974 to 1978, imports showed a slight recession before increasing again after 1982. Fig. 2 breaks down U.S. imports into relative market shares among the important exporting markets. The main origin of U.S. imports has historically been Australia, with a 14-year average of approximately 60% of the US import market. Australian exports to the US have been most important in 1975 and between 1980 and 1982. Since then, they have

[4,5] Endnotes on p. 74.

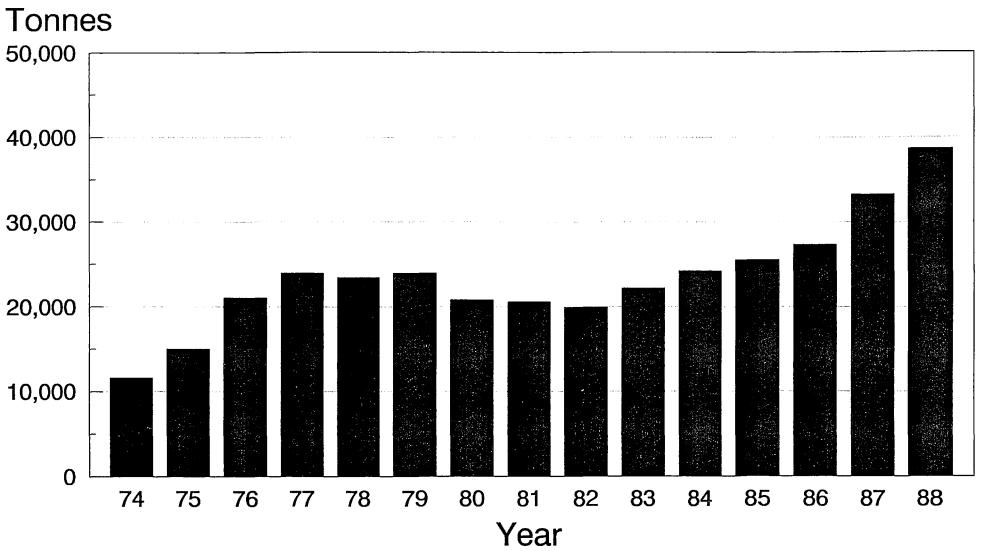

Fig. 1. Net quantity of U.S. imports of wheat gluten. Source: U.S. Department of Commerce, Bureau of the Census.

decreased slightly. Canada ranked second in importance as a supplier of US imports of wheat gluten. Since 1975, its market share has slowly decreased, from about 30% to 25%. Canada is now ranked third.

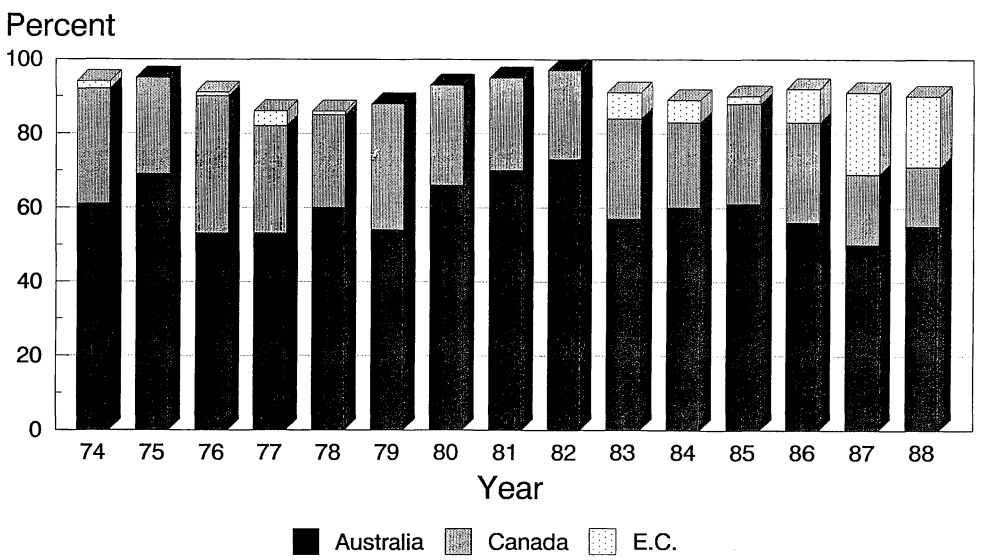

Fig. 2. Market shares of U.S. imports of wheat gluten. Source: U.S. Department of Commerce, Bureau of the Census.

In 1983, trade in wheat gluten between the E.C. and the US began to attain significance. After a slowdown in exports from the E.C. in 1985, its market share has grown to such an extent that it is now the second largest supplier of wheat gluten to the US, providing 22% of imports in 1987. The recent prominence of the E.C. as an exporter of wheat gluten parallels its new role as a net exporter of grains. These changes have occurred, in part, due to large grain surpluses in the E.C., which have arisen because of high support prices and expanding production (Hathaway, 1987). In addition, "the net price paid by the wheat-washing industry for E.C. wheat declined relative to both the net price paid by the corn wet milling industry for corn and the threshold price for hard wheat. These shifting price ratios encouraged both a shift from corn starch to wheat starch and from hard wheat flour to gluten-fortified E.C. flour" (Leuck, 1990, p. 7). Variable import levies and export subsidies for starch and wheat gluten protect these industries. However, during the past two years no export subsidies have been granted by the E.C. for wheat gluten, because of an elevated world price. Others countries have represented an average of 8.7% of the U.S. import market for wheat gluten, having a maximum of 14.5% in 1978 and a minimum of 2.72% in 1982.

AN ECONOMETRIC ANALYSIS OF THE U.S. IMPORT DEMAND FOR WHEAT GLUTEN

In light of the prominent role U.S. imports play in the international market for wheat gluten, it is of interest to empirically examine factors which are related to the demand for imported wheat gluten into the U.S. An expression for the import demand for wheat gluten in the U.S. can be developed from a consideration of factors that influence domestic demand and supply conditions for wheat gluten. Import demand is defined as the difference between domestic demand and domestic supply at a given price (i.e., the excess demand):

$$\mathrm{ID}_t = D_t^{\mathrm{d}} - S_t^{\mathrm{d}} \tag{1}$$

where D_t^{t} represents the domestic demand function, and S_t^{d} represents the domestic supply function (each in quantity-dependent form). We will assume that:

$$D_t^{\mathrm{d}} = f\left(D_{t-1}^{\mathrm{d}},\ P_t,\ p_t^{\mathrm{s}},\ p_t^{\mathrm{c}},\ y_t,\ x_t\right) \tag{2}$$

and

$$S_t^{\mathrm{d}} = f\left(S_{t-1}^{\mathrm{d}},\ P_t,\ z_t\right) \tag{3}$$

where D^{d}_{t-1} and S^{d}_{t-1} are lagged values of D^{d}_{t} and S^{d}_{t}, p_t is the price of wheat gluten, p^{s}_{t} is the price of substitutes, p^{c}_{t} is the price of complements, y_t is a measure of income, and x_t and z_t are other exogenous demand and supply shifters. Lagged values of quantities supplied and demanded are included to allow for partial adjustment. Since wheat gluten is a storable commodity and because of the significant lags often associated with international trade in basic commodities, incomplete adjustment in production, consumption, and trade quantities is suspected.

Because there are no close substitutes for wheat gluten, we can eliminate p^{s}_{t} from equation (2). A consideration of equations (1) through (3) yields the following expression for the demand for imported wheat gluten:

$$\text{ID}_t = f(\text{ID}_{t-1}, p_t, p^{c}_{t}, y_t, z_t, x_t) \tag{4}$$

Equation (4) is used to evaluate the U.S. import demand for wheat gluten. Monthly observations on relevant variables were collected for the period covering 1974 through 1988. The dependent variable is the quantity of wheat gluten imported by the U.S. Monthly prices were calculated in unit value form from the total (c.i.f.) value of monthly U.S. wheat gluten imports. Import quantities and values were provided by the U.S. Department of Commerce, Bureau of Census. Because flour is the main complementary product, the seasonally unadjusted Consumer Price Index for flour is used as the price of a complement good (obtained from the Department of Labor, Bureau of Labor Statistics). In addition, flour is also an input into the production of vital wheat gluten and thus may also influence domestic supplies. Wheat gluten is an industrial product, therefore the industrial income effects on import demand are accounted for by the Index of Industrial Production, collected from the OECD's *International Financial Statistics* series. [6] Price and income variables were deflated by the U.S. index of the producer prices for industrial goods, also collected from the OECD's *International Financial Statistics* series.

Because wheat gluten is mainly used as a protein complement in the milling and baking sector, it is necessary to consider the value of U.S. domestic wheat protein supplies. A measure of the value of high protein wheat relative to low protein wheat was calculated by taking the ratio of the monthly price of Minneapolis Dark No. 1 spring wheat (15% protein) to the price of Minneapolis Dark No. 1 Spring wheat (13% protein). These wheat prices were collected from selected issues of the USDA's *Wheat Situation and Outlook*. Higher protein premiums for domestic wheat are

[6] Endnote on p. 74.

TABLE 1

Box–Cox estimates of the U.S. import demand for processed wheat gluten

Variable	Estimate	Asymptotic t-ratio *	Implied elasticity **
Intercept	0.3222	0.4618	0.1797
ID^{d}_{t-1}	0.6090	10.3340 *	0.6074
p_t	−0.7701	−2.3323 *	−0.2732
p^{c}_{t}	−0.1590	−4.0989 *	−0.6067
y_t	0.1585	3.3585 *	0.5261
pp_t	1.0714	3.6974 *	0.6177
ρ ***	−0.4300	−6.3900 *	
λ	0.4000		
R-square	0.5961		
SSE	26.2370		

* * denotes significance at the 5% level.

** Elasticity estimates are evaluated at the mean data values.

*** First-order autoregressive parameter estimate.

expected to increase imports of gluten. [7] The relative value of U.S. domestic wheat protein is thought to be one of the main factors influencing the demand for wheat gluten by many in the industry (Hesser, 1989).

Economic theory provides little guidance in making the transition from the theoretical relationship implied by equation (4) to a specific functional demand equation suitable for empirical estimation. Alternative functional forms often applied in the estimation of empirical demand relationships include linear and logarithmic functions. However, in lieu of specific information that provides a clear indication of the correct choice of functional form, it may be advantageous to utilize a more flexible alternative. In this application, we utilize the Box–Cox flexible functional form, which performs a parametric transformation on the demand equation variables, allowing a degree of flexibility in the demand function specification. The Box–Cox (1964) flexible functional form of equation (4) can be written as:

$$(ID_t^{\lambda} - 1)/\lambda = \beta_0 + \beta_1(ID_{t-1}^{\lambda} - 1)/\lambda + \beta_2(p_t^{\lambda} - 1)/\lambda + \beta_3(p_t^{c\lambda} - 1)/\lambda + \beta_4(y_t^{\lambda} - 1)/\lambda + \beta_5(pp_t^{\lambda} - 1)/\lambda + \varepsilon_t \quad (5)$$

where $\beta_0, \ldots, \beta_5$ and λ are parameters to be estimated.

Maximum likelihood parameter estimates and relevant summary statistics for equation (5) are presented in Table 1. These estimates were

[7] Endnote on p. 74.

obtained through an iterative procedure, which first chooses the λ that minimizes the sum of squared errors and then estimates the β_i's conditional on the estimate of λ. Each of the coefficient estimates has the expected sign and are significant at the 1% level, with the exception of the intercept. Significant autocorrelation was detected in the initial estimates. Autocorrelaton was corrected by simultaneously estimating an autoregressive parameter using the method described by Savin and White (1978). This autoregressive parameter was significant at the 0.01 level, verifying the presence of autocorrelation. Table 1 also contains (short-run) elasticity estimates for the import demand for wheat gluten, evaluated at the sample data means.

The own-price effect for the import demand for wheat gluten implies an elasticity of -0.27 which indicates an inelastic import demand. This finding is in agreement with the views of individuals familiar with the industry (Hesser, 1989), who assert that the international market is not especially responsive to price changes. Lagged imports are significant in the import demand equation and imply an elasticity of 0.61. This indicates a significant degree of partial adjustment in monthly wheat gluten flows into the U.S. In this light, long-run elasticities would be expected to be approximately 2.55 times larger than the reported short-run elasticities.

The price of flour appears to be a significant factor in the determination of imports of wheat gluten. Its coefficient is highly significant with a negative sign that reflects flour's role as a complementary product with wheat gluten. The coefficient estimates correspond to a cross-price elasticity of about -0.61. The index of industrial production, representing income effects, is also highly significant. The income variable has a value of 0.16, corresponding to an income elasticity of 0.53, indicating an income-inelastic import demand for wheat gluten. Such a finding is common for food items, which are usually considered to have income-inelastic demands.

The value of U.S. domestic wheat protein also appears to be a significant determinant of U.S. imports of wheat gluten. The protein value variable has a significant positive sign, indicating that higher costs for high protein wheat relative to lower protein wheat increases the demand for imports of wheat gluten. The short-run elasticity estimate has a value of 0.62, indicating a relatively inelastic response to increased costs for domestic protein.

In all, these results indicate that the U.S. import demand for wheat gluten is significantly influenced by the price of a complementary product (flour), by income, and by the domestic availability of wheat protein. The results also reveal that the import demand for wheat gluten is price inelastic. In particular, changes in the price of imported wheat gluten exhibit a significant but inelastic effect on imports. Finally, a significant degree of partial adjustment was revealed through highly significant lagged

values of imports. The coefficient on lagged imports implies that long run elasticities are approximately 2.55 times short run elasticities.

CONCLUDING REMARKS

This paper has considered international trade in a processed agricultural product, wheat gluten. Although the U.S. is a major exporter of wheat products and a major producer of high-protein wheat, it is also the world's largest importer of processed wheat gluten, an important product derived from milled wheat. Several factors, including E.C. agricultural programs for wheat, have contributed to the development of this international market.

The analysis also includes an econometric evaluation of the U.S. import demand for wheat gluten. The results of this econometric analysis indicate that the U.S. demand for imported wheat gluten is influenced by the price of gluten, the price of flour, a measure of industrial income, and by the cost of domestic wheat protein, an important ingredient in processed grain and cereal products. The import demand for processed wheat gluten was shown to be price and income inelastic. This suggests that export subsidies on the part of the E.C. might not be completely successful in boosting E.C. exports of wheat gluten to the U.S.

Additional research into production interrelationships between wheat gluten and wheat starch and corn sweeteners, corn starch, and corn gluten might provide additional insights into factors which that shaped the international market for wheat gluten. Important avenues for future research include an assessment of high-protein wheat displacement by vital wheat gluten and an evaluation of trends in world starch industries which may impact the vital wheat gluten industry. In addition, a clearer understanding of these relationships might clarify knowledge of the impacts of trade policy on international trade in processed agricultural products.

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ENDNOTES

[1] An output of 1 ton of wheat gluten corresponds to the recovery of 5.25 tons of wheat starch and up to 30 tons of liquid effluent containing 1.1 tons of soluble starch and fiber (Grace, 1989).

[2] In the U.S., great research efforts have led to a near perfect knowledge of the corn wet milling process, a technique that has still not been completely mastered for wheat. Furthermore, the corn starch industry has profited from a better reputation of its products (Debatisse, 1987). Consequently, wet milling companies in the U.S. are the only ones that can be considered as corn gluten producers, with starch being a by-product of their activity.
[3] The wheat gluten, wheat wet milling, or wheat washing industry is the industry which separates wheat flour into starch, gluten, and other minor components using water.
[4] In 1988, the average price of vital wheat gluten was 49.9 cents per pound. For the same year, the average Kansas City price of Bakers' Standard Patent flour was below 10 cents per pound.
[5] In the U.S., important uses for imported wheat gluten include its addition as a dough-strengthening component in specialty bread products (e.g., multigrain breads and hot-dog and hamburger buns) and as a protein complement and binder for vitamin and mineral enrichment components in breakfast cereal products. An example is the Kellogs Company's 'Special K', which has a wheat gluten content of about 7–10% (IWGA, 1989).
[6] An alternative measure of income, disposable personal income, was also considered. The index of industrial production was chosen on the basis of its superior empirical performance as well as for the fact that it is likely to be a more relevant demand shifter for wheat gluten, in light of its industrial uses.
[7] An alternative measure of U.S. domestic wheat protein abundance was also considered. The chosen indicator was a weighted average of the protein amount of the wheat harvest in North Dakota and Kansas. This variable and its influences on U.S. wheat gluten imports is described in detail in Ortalo-Magné and Goodwin (1990). The alternative measures of domestic protein abundance gave very similar results and implications for U.S. vital wheat gluten imports.

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