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Determinants of Red Meat Trade Flows

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Highlights

Theoretically, trade flows of commodities, are determined on the basis of comparative advantage. In practice, trade flows of agricultural commodities such as red meat are distorted by government interventions. The actual determinants of trade flows of red meat are thus subject to much uncertainty. The objective of this study is to evaluate factors affecting trade flows of meat and to analyze effects of trade policies used by exporting and importing countries on the world meat trade.

A reduced form gravity model, derived from a partial equilibrium model of world trade, was applied to the world meat market to evaluate factors affecting meat trade flows. The model was estimated by using a pooling technique for time series and cross-section data.

Long-term agreements and the formation of economic unions stimulate meat trade among members while import quotas and hoof and mouth disease restrictions impairs meat trade. Distance between trading partners and sharing common border are also important trade determinants.

The U.S. and Canadian Free Trade Agreement will enhance trade flows of meat between these two countries. The North American Free Trade Agreement (NAFTA), which is under negotiation among United States, Canada, and Mexico, will restore comparative advantage as a major determinant of trade and increase trade volume among these three countries. Eliminating producer and consumer subsidies through multilateral negotiations will enhance trade flows of red meat among countries.

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INTRODUCTION

Most meat exporting countries compete with one another to increase their market shares in the world meat market. To further promote bilateral trade, some exporting and importing countries have signed bilateral Long-term Trade Agreements. In exporting countries, systems of variable subsidies to producers have been enacted to promote exports. In importing countries, excise taxes have protected domestic industries. Other countries have used import quotas to protect domestic meat industries.

In a free trade system, trade flows of commodities generally are determined on the basis of the principle of comparative advantage. Since trade flows of meat are distorted by government interventions, determinants of trade flows of meat and their economic effects are not clear. The objective of this study is to evaluate factors affecting trade flows of meat and to analyze effects of trade policies used by exporting and importing countries on the world meat trade.

Most researchers in this area have used spatial equilibrium models based on mathematical programming algorithms [Takayama and Judge (1964); Bawden (1966); MacKinnon (1976); and Koo (1984)]. In these studies, trade flows are explained by the prices of commodities in importing and exporting countries and by transportation costs between countries. Thompson (1981) and Dixit and Roningen (1986), however, indicate that spatial equilibrium models perform poorly in explaining trade flows of commodities that are distorted by exporting countries' export promotion programs and importing countries' protection policies. We used a commodity specific gravity model to account for the factors that are unique to pairs of countries involved in trade.

Formal theoretical foundations for gravity equations are provided in Anderson (1979) and Bergstrand (1985, 1989). In the gravity model, trade flows of an aggregate commodity are explained by the following variable components: (1) economic factors affecting trade flows in origin countries, (2) economic factors affecting trade flows in destination countries, and (3) natural and artificial factors enhancing and resisting trade flows. In this study, the gravity model is respecified for a specific commodity and applied to trade flows of meat.

Unlike traditional gravity models that use cross-section data, parameterizing the gravity model with pooled time-series and cross-series data greatly improves the efficiency of the results. The formulation permits the use of information available over several years for each pair of trading countries. We demonstrate how Hausman specification tests and Lagrange Multiplier tests were used to choose between competing models. Panel data allow construction and testing of trade effects, normally not possible for purely cross-section and time-series models. The results provide strong evidence that single commodity trade models should include trade policies and be subject to specification tests.

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The World Red Meat Industry and Trade

The international trade of red meat is concentrated among less than 20 countries. The red meat classification consists of beef, pork, and lamb. Since international statistics are not available for the individual classes of red meat, Standard Trade Industry Classification (STIC) number 011 for fresh, frozen, and chilled red meat is used.

World trade in red meat has grown from $7.28 billion in 1973 to $21.5 billion in 1987. The value of international red meat trade is less than 1% of total agricultural trade, but in 1987, $21.5 billion (U.S.) were traded among countries (U.N. International Trade Statistics Yearbook).

The six largest exporters for 1973 and 1987 are shown in Table 1. During the past 14 years, the trade flow of red meat has changed substantially. Australia, the top exporter in 1973, fell to fifth place in 1987. Argentina was in fourth place in 1973 but was not among the top six exporters in 1987. In 1973, the European Community (E.C.) countries exported 38% of the world exporters of red meat. In 1987, the E.C., exported 61% of the red meat traded in the world market.

TABLE 1. LARGEST RED MEAT EXPORTING COUNTRIES, 1973 AND 1987

1973		1987	
Country	Percentage	Country	Percentage
Australia	18	Netherlands	16
Netherlands	13	France	9
New Zealand	11	Denmark	9
Argentina	9	United States	9
Denmark	6	Australia	9
United States	6	Germany	8
(E.C.)	38	(E.C.)	61

SOURCE: U.N. International Trade Statistics Yearbook.

The largest six importers of red meat for 1973 and 1987 are shown in Table 2. Japan's large increase in imports was the major change. The percentage of E.C. imports remained practically unchanged, 51% in 1973 vs 53% in 1987. The percentage of the U.S. imports decreased from 12% in 1973 to 10% in 1987.

Table 3 presents exporting countries' average market shares for red meat from 1985 to 1987. The largest market share in each importing country is underlined. Belgium has the largest market share in the Netherlands; the Netherlands has the largest market share in France, Germany, Belgium and Italy; Germany has the largest market share in Greece; United States has the largest market share in Canada and Japan; France has the largest market share in Switzerland; Australia has the largest market share in United States; and New Zealand has the largest market share in United Kingdom. Most exporting countries also import meat from other exporting countries. For example, the United States is the largest exporter to Japan and Canada and the largest importer from Australia. The Netherlands is the largest exporter to its neighboring countries and the largest importer from Belgium.

TABLE 2. LARGEST RED MEAT IMPORTING COUNTRIES, 1973 AND 1987

1973		1987	
Country	Percentage	Country	Percentage
Italy	16	Japan	15
Germany	15	Italy	14
United States	14	Germany	12
United Kingdom	12	France	12
France	11	United States	10
Japan	10	United Kingdom	6
(E.C.)	51	(E.C.)	53

SOURCE: International Trade Statistics Yearbook.

Major exporting and importing countries' production and marketing systems are stated as follows.

European Community

The European Community (E.C.) countries, including Belgium, Denmark, France, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom, and West Germany, will be described together because of similar production practices and government policies. The production of livestock in Europe is concentrated on small 20- to 40-ha farms. Animals in the northern countries are sheltered during the winter (Simpson 1982). Europe does not have the large breeding or feeding units that are common in the United States. A farmer maintains ownership of the animal from birth to market. The stages of production are not specialized among individual farms.

Animals are fed a ration of forage because of the high cost of grain and concentrates. Hog production is more specialized in Europe than beef, but individual farms farrow, feed, and finish the hogs. Confinement units are similar to those in the United States.

United States

U.S. livestock systems are specialized in stages of production. Western cow-calf operations provide calves for feedlots in the Great Plains and the Corn Belt. Farrowing operations provide young pigs for confinement feeding operations in the Midwest. Transportation has been a leading factor in the U.S. livestock system. Truck transportation allows the livestock to be shipped to the feedlot.

TABLE 3. EXPORTERS MARKET SHARE, THREE YEAR AVERAGE, 1985-1987, FOR RED MEAT TRADE.

Importing Countries	QUANITY IMPORTED METRIC TON	Exporting Countries																
		ARG	SWE	USA	URG	GER	FRA	BEL	CAN	BRA	NETH	UK	AUS	NZ	DEN	IRE	YUG	OTHER
Italy	1001087	.012	.007	.002	.002	.171	.123	.066	.000	.018	.303	.008	.001	.006	.121	.004	.023	.132
Germany	995693	.010	.004	.000	.004	.000	.095	.067	.000	.013	.483	.058	.006	.013	.000	.000	.003	.122
USA	937342	.000	.000	.000	.000	.000	.000	.001	.000	.324	.000	.000	.361	.210	.059	.002	.000	.044
France	902849	.011	.005	.000	.002	.121	.000	.176	.009	.007	.228	.152	.005	.010	.074	.080	.000	.118
Japan	794391	.020	.005	.300	.000	.000	.003	.000	.028	.039	.000	.001	.224	.061	.111	.007	.000	.199
UK	547253	.013	.007	.054	.019	.021	.078	.005	.021	.023	.076	.000	.030	.294	.102	.243	.000	.016
Greece	227456	.000	.000	.001	.004	.380	.066	.033	.000	.000	.278	.000	.010	.060	.053	.001	.031	.076
Belgium	172592	.037	.007	.100	.003	.101	.128	.000	.010	.014	.399	.080	.015	.023	.010	.020	.000	.055
Netherlands	158479	.066	.002	.109	.019	.114	.094	.324	.016	.050	.000	.087	.028	.033	.005	.024	.000	.029
Canada	144074	.000	.000	.296	.000	.000	.000	.001	.000	.000	.001	.001	.240	.222	.064	.020	.000	.154
Swit	61429	.075	.001	.027	.002	.024	.244	.002	.087	.018	.040	.043	.021	.034	.020	.001	.000	.362

Animals are fed a high concentrate diet because of the availability and low cost of grain. The high fixed cost associated with modern livestock facilities requires high volume and short feeding time.

Australia

Australian livestock production is generally part of a mixed enterprise or ranching system. In the more arid areas, large ranches graze livestock from birth to slaughter weight year round. Animals are grazed until two or three months before slaughter, when they are fed forage with a small amount of concentrate or grain.

Latin America

Extensive cattle operations are spread throughout Latin America from Mexico to Chile. The major world exporters include Argentina, Brazil, and Uruguay. A typical system in Latin America is a cow-calf operation where calves are kept on the ranch and fed on native or improved pastures for up to four years. The animals weigh 880 to 1100 lbs at slaughter. The livestock production system is similar to Australia's.

Japan

Japan is one of the major importers of red meat. Most beef imports come from Australia, Canada, New Zealand, and the United States. Small farms raise feed cattle like family pets for two or three years. Animals are sold to individual slaughter yards for as much as $10,000 (Longworth 1984). Most beef produced in Japan is from a dual purpose type of animal, dairy and beef. The diet of Japan has been westernized since the 1950s. The consumption of beef has increased four times since 1960 while pork has increased twelve times.

Trade Policies in Red Meat Trade

Non-tariff barriers (NTB) surfaced after the Kennedy Round (1963-67) of GATT negotiations. Tariffs have been reduced as a result of GATT negotiations, leaving NTB behind.

A basic list of NTB consisting of 800 items was made by GATT after the Kennedy Round. Many NTB exist among major importing countries. With the removal of many tariffs, countries have turned toward NTB to limit imports and protect producers. The major NTB affecting the trade of red meat are quotas, licensing requirements, health and sanitary laws, marketing standards and labeling, and bilateral trade agreements.

A measure of total governmental intervention is being developed because of GATT. The producer subsidy equivalent (PSE) is an estimate of the amount of cash subsidy needed to compensate producers if all government support were removed (USDA). It can be positive or negative, depending on the individual country's policy. A negative PSE implies that the government is taxing the producers to benefit consumers.

Consumer subsidy equivalent (CSE) is the amount that the consumer price would decrease if all government intervention within the market would end. CSE is generally negative. PSEs and CSEs are expressed as a percentage of the value of production or consumer cost.

PSE and CSE are designed to capture the value of all forms of government intervention, including production subsidies, export enhancements, and import restrictions. The PSE and CSE for some major importers and exporters of red meat are shown in Table 4.

A Japanese livestock producer's income would decrease by 66% if the government intervention were absent. Producers in E.C. and other Western European countries would receive 37% and 50% less, respectively.

TABLE 4. PSE AND CSE OF SELECTED EXPORTING AND IMPORTING COUNTRIES OF RED MEAT TRADE

Country	PSE[a]	CSE[b]
	--------Percentage--------	
United States	10	-1
Canada	10	0
E.C.	37	-19
Western Europe	50	-26
Japan	66	-34
Australia	5	0
New Zealand	9	0
Brazil	-22	0
Argentina	-48	27
Egypt	46	-27
South Korea	48	-57

[a]PSE is the amount of cash subsidy needed to compensate producers if all government support were removed.
[b]CSE is the amount that the consumer price would decrease if all government intervention within the market would end.

SOURCE: USDA. A Database for Trade Liberalization Studies, 1989.

E.C. and Other European Nations

The European Community (E.C.) Common Agricultural Policy (CAP) was started in 1958 with the following objectives: to increase agricultural productivity by developing technical programs and by ensuring the rational development of agricultural production and optimum use of the factors of production, particularly labor; to ensure a fair standard of living; to stabilize markets; to guarantee regular supplies; and to ensure a reasonable price for consumers (Patterson).

The E.C.'s main support for red meat production is the variable levy. It separates world market influences from the domestic market. Producers receive a direct per-head price support depending on individual production costs. Producers with poorer land or higher feed costs also are subsidized. A slaughter premium for dairy cattle reduces the dairy product surplus, but the increased supplies of beef add to the surplus which must be exported with the aid of an export subsidy. The exporters are reimbursed, allowing them to sell red meat at the lower world price. The costs involved with the price support, slaughter premium, and export subsidy transfer welfare from consumers to producers, export firms, and processors.

The producer is protected from international market forces by a series of price supports and import restrictions. Production increased dramatically in the 1970s and 1980s. E.C. production of red meat grew from 14.1 million metric tons in 1973 to 21.5 million metric tons in 1987 (FAO Production Yearbook).

In January 1989, the E.C. prevented importation of meat that had been grown using artificial growth hormones (USDA). This order has limited the supplies of red meat acceptable to the E.C. market.

A major problem within the E.C. is the control that each government maintains over its own trade matters. Red meat has no common minimum standard. Each member retains its own standards. The conflicting standards present a major barrier for trade (Ojalla 1985).

Hoof and mouth disease is common in the southern half of the E.C., while Denmark, Ireland, and United Kingdom have none. The United Kingdom bans beef imports from infected areas unless the cuts are deboned, have the lymph glands removed, and are shipped in anatomical sections. The health and sanitary restriction limits trade from infected areas.

The other countries in Europe maintain substantial trade protection for red meat. Numerous policies similar to those of the E.C. are used. Austria, Finland, Norway, Sweden, Switzerland, and Yugoslavia use export subsidies to reduce surpluses. Subsidies are funded by producers in Finland, Norway, and Sweden. Variable levies are used in Austria, Finland, and Sweden, while import quotas are used by Norway, Switzerland, and Yugoslavia. Finland, Norway, Sweden, and Switzerland subsidize producers to maintain production in the northern areas or at higher elevations. A hormone ban similar to the E.C. is in effect in Sweden. A target price scheme is used in Finland, Norway, Sweden, and Switzerland to protect producers' incomes.

United States

Until 1964, tariffs were the major protection mechanism used in the United States. Tariff levels were reduced from 47% in 1934 to 6% in 1987 (USDA). Section 22 of the Agricultural Adjustment Act authorizes the U.S. President to impose fees or quotas in addition to the basic tariff if foreign competition interferes with any price support or reduces the amount of any agricultural product processed within the United States.

In 1964, Public Law 88-481 placed an import quota on all beef imported into the United States, based on previous import levels. In 1979, the Meat Import Act set the quota level, based on past import volume weighted by three- and five-year moving averages of meat production. Each quarter, the U.S. Secretary of Agriculture must estimate the quantity of imports. If the estimated level reaches a maximum quota level, the U.S. President must place quotas on those countries exporting to the United States. In the case of national disaster, disease, or major national market disruption, the law provides for the suspension or enlargement of the quota (Petry).

In 1987, the United States and Canada signed the U.S.-Canada Free Trade Agreement to eliminate tariffs on all traded goods by 1998 and to eliminate import quotas and export subsidies. The health and sanitary provisions of both countries remain in force, but the agreement states that negotiations will continue to standardize the health and sanitary provisions (USDC 1988).

The United States maintains a ban on fresh, frozen, and chilled beef from countries with hoof-and-mouth disease. This prevents imports from Argentina, Brazil, and much of Europe, unless the meat is canned or processed. All imported meat is federally inspected, just like domestic meat.

U.S. producers may be subsidized by reduced interest rates through FmHA loans, below market grazing fees, compensated fees for federal inspection services, research and education, and disaster aid (Simpson 1982). U.S. producers do not receive cash subsidies like other industrial countries.

Canada

Imported fresh, frozen, and chilled meats are restricted by provisions of the Meat Import Act in Canada which maintains stable producer prices within 90% of a five-year average (Simpson 1982). Payments are made directly to producers. Similar to the U.S. Import Act, it sets an import quota on imports. The quota provisions of the Act have not been implemented.

In 1973, Canadian exports to the United States were $118.7 million compared to U.S. exports to Canada of $64.4 million; by 1987, Canada exported $577.8 million while the United States exported $103.6 million (USDA).

Canada maintains a strict set of health and sanitary regulations. All imports must be inspected by a veterinarian before importation. These regulations are the main barriers to trade between the United States and Canada.

Japan and Other Asian Countries

The Occupation forces turned over import licensing to the Japanese government in 1950. Initial imports were feedstuffs for domestic production of livestock products. Production of pork increased ten-fold between 1960 and 1980 while beef increased three-fold during the same period. A high support program was implemented to increase domestic production. A formula was developed to create a price band of minimum and maximum prices to support and stabilize producers' income. The price band is determined yearly, with the quota levels depending on the price levels (Longworth 1984). A market price near the maximum would increase quota levels. The Livestock Industry Promotion Council (LIPC) administers the domestic price support program and import quotas, and holds and releases all imports, depending on domestic price. Imports are released to the

National Federation of Agricultural Coop. (ZENNOH), which determines the final destination of the meat.

Japan has two separate quotas for beef, a General quota and a High Quality Beef quota (HQB), which were established in 1977 because of negotiations with the United States. In 1987, Japan signed the Beef and Citrus agreement, which phases out the import quota by 1991 (USDA).

The HQB quota will remain at 58,400 metric tons under the agreement. The general quota will rise to 394,000 metric tons in 1990 before being eliminated. If imports grow by 120% of the previous year after 1991, an additional tariff will be added (USDA). HQB is imported from the United States, and Popular grade is imported from Australia and New Zealand, under the General quota. High quality U.S. choice beef competes with the best-quality Japanese dairy beef. Popular grade is grass-fed Oceanic beef and competes with second-grade dairy beef.

South Korea's market is highly restrictive. All imports are purchased by the Livestock Product Marketing Organization. Beef imports are restricted to 14,500 metric tons per year (USDA). Pork imports are controlled through state licensing, which amounts to a virtual ban on imports. Producers are subsidized through price stabilization and subsidized credit.

Taiwan maintains a Bilateral Trade Agreement with the United States. Tariffs in Taiwan have risen to 50% of cif price.

The Philippines requires an import license for all red meat. The licenses only are issued to five-star hotels and certain processing companies. A 20% tariff is added to import prices.

Australia and New Zealand

Australia's level of producer assistance is low and limited to federally funded research programs, disease control, and production tax concessions. An export marketing program is producer funded with a small tax on all sales.

New Zealand's price is stabilized by a price smoothing program that removes the peaks and valleys from the price cycle. A LTA between New Zealand and Australia allows free access to each other's markets. Australia does not allow imports of meat, except from New Zealand, because of strict animal health standards. New Zealand's markets are protected with a 20% tariff. Both countries are hoof-and-mouth disease free and ban all imports from infected countries.

Latin America

Argentina maintains a low domestic price to enhance domestic consumption. Consumers are subsidized at the expense of producers. Export taxes are charged on all exports. Cattle numbers have fallen from 59 million in 1977 to 51 million in 1987 (FAO). Argentina imports no red meat. Import licenses are required for all imports. Licenses are not issued for luxuries or domestically available goods.

Hoof-and-mouth disease is native to South America which restricts export markets. A major portion of meat exports are either canned or cured.

Brazil's policies are similar to Argentina's; it subsidizes consumers at the expense of producers. All exports are taxed and are regulated by a quota. Domestic prices are maintained at a low level. Imports are restricted because of a shortage of foreign exchange and state licensing. The license is denied if a similar domestic product is available. Brazil maintains a LTA with Argentina and is negotiating one with Canada.

Uruguay's government does not interfere with the export market but does ban most imports. Producers receive little assistance from the government.

Costa Rica maintains a two-price system, a low export price and a high domestic price. Producers receive subsidized credit from the government at below-market levels. Imports are restricted with permits that are issued only after all relevant producer organizations are contacted. Costa Rica is a member of the Central American Common Market. Member countries are not subject to these restrictions.

Arab Countries

Saudi Arabia's production, although small, is highly subsidized. Imports are not restricted. However, all labels must be bilingual and detailed.

The Egyptian government subsidizes most agricultural inputs, including interest rates, water, and pesticides. They offer no export incentives for red meat. LTA are maintained with Australia, France, and Eastern Europe. Most imports are handled by the state. Private importing is discouraged and requires previous deposits, limited foreign exchange, and subsidized government marketing. Egypt maintains strict health and sanitary regulations.

The Econometric Model

The gravity model has been used to evaluate bilateral trade flows of aggregate commodities between pairs of countries. A gravity model is a reduced form equation from partial equilibrium of demand and supply systems. Bergstrand (1985, 1989) generated a gravity model by solving the consumer's demand function and the firm's supply function simultaneously, under an equilibrium condition. Unlike traditional gravity models of aggregate trade [Linnemann (1966), Bergstrand (1989), and Aitken (1973)], a commodity specific gravity model can incorporate the unique characteristics associated with trade flows of a specific commodity.

Consumer theory is used to derive the import demand functions. Various assumptions are made to simplify the consumer demand model. Consumers in the importing country have identical utility functions and require a minimum level of consumption.

The demand equation for the specific commodity is derived from maximizing the constant elasticity of the substitution (CES) utility function subject to an income constraint. The supply equation can be derived from the firm's profit maximization problem in exporting countries with resource inputs allocated according to constant elasticity of transformation (CET) during the production process.

The commodity specific gravity model, under market equilibrium conditions of demand and supply systems, can be derived as follows:

$$X_{ij} = \alpha Y_i^{\alpha_1} Y_j^{\alpha_2} C_{ij}^{\alpha_3} T_{ij}^{\alpha_4} P_i^{\alpha_5} P_j^{\alpha_6} E_{ij}^{\alpha_7} I_i^{\alpha_8} I_j^{\alpha_9} e_{ij} \quad i=1, 2, \ldots N \text{ and } j=1, 2, \ldots M \qquad (1)$$

where X_{ij} is the volume of commodity traded from country i to country j; Y_i (Y_j) represents income of country i (j); C_{ij} is transport cost (c.i.f./f.o.b.) between i and j; T_{ij} is j's tariff on the commodity imports; P_i (P_j) is the price of the commodity at country i's export port (country j's import port); E_{ij} is the spot exchange rate of country j's currency in terms of country i's currency; I_i (I_j) represents aggregate price index in respective countries; and e_{ij} is the random error term. Equation (1) is derived theoretically in Bergstrand (1985); a brief summary is provided in the appendix.

An exporting country's income can be interpreted as the country's production capacity, while an importing country's income is the country's purchasing power. Since total farm income is more closely related to red meat production than the country's income, the model uses total farm income as an exporting country's income variable. It is expected that trade flows are positively related to the exporting and importing countries' income. Transportation costs and tariffs, which are trade barriers, are assumed to be negatively related to volume of trade flows. The prices of a commodity in exporting and importing countries are important in determining trade flows. A commodity moves from a country in which the prices of the commodity are low to countries in which the prices are high. Exports are hypothesized to be positively related to changes in export prices and imports are negatively related to changes in import prices. An exporting country with high inflation tends to substitute foreign imports for domestically produced goods, resulting in increases in imports. Exchange rates are one of the most important factors affecting trade flows. Appreciation of a country's currency against other currencies reduces the country's exports and increases imports, and depreciation produces the opposite effects.

Unlike traditional gravity models of aggregate good trade in Bergstrand (1985, 1989), Anderson (1979), and Linnemann (1966), the commodity specific gravity model can incorporate the unique characteristics and policies associated with trade flows of the specific commodity used by exporting and importing countries. In meat trade, exporting countries use various export promotion programs, including long-term agreements between pairs of trading countries and subsidies for producers.

Hoof-and-mouth disease is one factor inhibiting trade flows. Many countries maintain a complete ban on beef imports from countries with hoof-and-mouth disease. Quotas are a major protection instrument imposed by importing countries. Subsidies to consumers are also an important means for importing countries to protect their domestic industry. Variables aiding and inhibiting trade flows of meat are included in this model. The trade aiding variables are expected to have positive effects on trade volumes, while those inhibiting trade are expected to have negative effects.

A dummy variable representing trade flows of wheat among European Community (EC) member countries also is included in the model. European economic integration is hypothesized to enhance meat trade among member countries. The model also includes another dummy variable representing border countries, under an assumption that more trade occurs between countries with a common border.

The empirical gravity model for meat trade is as follows:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} D_{ij}^{\beta_3} P_i^{\beta_4} P_j^{\beta_5} E_{ij}^{\beta_6} I_i^{\beta_7} I_j^{\beta_8} N_i^{\beta_9} N_j^{\beta_{10}} G_i^{\beta_{11}} G_j^{\beta_{12}} PS_i^{\beta_{13}} CS_j^{\beta_{14}} e^{\beta_{15} ED_{ij}} e^{\beta_{16} AD_{ij}} e^{\beta_{17} LTA_{ij}} e^{\beta_{18} HMD_{ij}} e^{\beta_{19} QUT_{ij}}$$
$$e^{\beta_{20} darg} e^{\beta_{21} dau} e^{\beta_{22} dat} e^{\beta_{23} dbra} e^{\beta_{24} dc} e^{\beta_{25} dec} e^{\beta_{26} dse} e^{\beta_{27} dur} e^{\beta_{28} dus} e^{\beta_{29} dyu} V_{ij} \qquad (2)$$
$$i = 1, 2, \ldots N; \quad j = 1, 2, \ldots M$$

where D_{ij} is distance between countries i and j used as a proxy for transportation costs; N_i (N_j) represents population size in country i (j); $G_i(G_j)$ represents grazing land in country i (j); PS_i (CS_j) represents producer (consumer) subsidy in country i (j): darg, dau, dat, dbra, dc, dec, dse, dus, dur, and dyu are dummy variables identifying, respectively, specific exporting countries: Argentina, Australia, Austria, Brazil, Canada, European Community, Sweden, the United States, Uruguay, and Yugoslavia; ED_{ij} is a dummy variable identifying trade flows among EC member countries; AD_{ij} is a dummy variable representing a common border; LTA_{ij}, QUT_{ij}, and HMD_{ij} are dummy variables representing, respectively, Long Term Agreements, quota, and hoof-and-mouth disease; and V_{ij} is the random error term. The Hoof-and-Mouth disease dummy represents the presence of the disease in exporting countries and a ban on imports from the infected countries. Producer subsidy equivalent (PS_i) is defined as an aggregate subsidy measure given to producers; similarly, consumer subsidy equivalent (CS_j) is defined as an aggregate subsidy measure given to consumers. Trade policy variables replace T_{ij} as factors enhancing or resisting trade flows in Equation (1).

Trade policies were not in force for every year and country during the study period. Some program values were zero at times. Thus, policy variables are coded into qualitative variables. Although we recognize that qualitative variables identify average effects, they do provide coherent results.

Econometric Procedures and Source of Data

Traditional gravity models similar to Equation (1) typically are used to describe aggregate trade flows [Linnemann (1966); Bergstrand (1985 and 1989); Summary (1989)]. Equation (2) includes trade policies used by exporting and importing countries. The new model should be subject to specification tests. A test statistic developed by Godfrey (1986, p. 77) indicates that with a 1 percent significance level, Equation (2) should be used in meat trade analysis. Computed LM value (84.562) exceeds the critical χ^2_{15} value (30.57). Alternatively, since Equation (1) is nested in Equation (2), the likelihood ratio test for specification (Kmenta 1986, p. 593) gives a likelihood ratio (123.35), which exceeds the critical χ_{15}^2 value (30.50) and also rejects the null hypothesis of no trade policy variable augmentation at the 1 percent significance level. The results mean that in modeling red meat trade flows, trade policies should be included.

Also, classical gravity models used cross-section data to estimate a relationship at a given time. However, in the real world, economic data may be available with useful information in a cross-section form observed over several years. This is especially needed for agricultural commodities for which trade flows are highly volatile due to weather conditions in importing and/or exporting countries. The estimated parameters of the equation with cross-section data for a particular year may not provide accurate information in evaluating trade flows of a commodity. Hence, in this study we propose to parameterize the econometric model in Equation (2) over time and cross-section units. A pooling technique combining cross-section and time series data, therefore, seems most appropriate and is described below.

Equation (2) should be expressed in time series and cross-section form as follows:

$$X_{ijt} = Z_{ijt}b + U_{ij} + \lambda_t + V_{ijt} \tag{3}$$

where X_{ijt} is trade observation from i to j at time t (t = 1, 2, ..., T); Z_{ijt} is a corresponding trade determinant vector; U_{ij} is the trade effect associated with the country pair i and j; λ_t is time specific to a particular year (the cross-section unit); and V_{ijt} is the random error term.

Technical problems associated with the estimation of Equation (3) have been discussed by Hausman (1978), Judge et al. (1985), and Hsiao (1986). Model 3 has the main advantage of allowing different individual and time effects for each country pair.

To test the null hypothesis, $U_{ij} = 0$ and $\lambda_t = 0$, the Breusch and Pagan (1979) show that

$$G = \frac{NT}{2}\left\{ \frac{1}{T-1}\left[\sum_{i=1}^{N_1} \sum_{j=1}^{N_2} \left(\sum_{t=1}^{T} e_{ijt} \right)^2 - 1 \right]^2 + \frac{1}{N-1}\left[\sum_{t=1}^{T} \left(\sum_{i=1}^{N_1} \sum_{j=1}^{N_2} e_{ijt} \right)^2 - 1 \right] \right\}^2 \tag{4}$$

has an χ^2 distribution with 2 degrees of freedom. In Equation 4, N = $N_1 \bullet N_2$ and e_{ijt} = OSL residuals. The test statistic was computed to be 676.83, exceeding $\chi^2_2 = 9.210$ at the 1 percent level and rejecting the null hypothesis. Since the effects U_{ij} and λ_t differ significantly from zero, whether the effects are fixed or random should be determined. The Hausman specification test is used to determine if the model has fixed or random effects (Hausmann 1978) The statistics specification test of a model based on the behavior of U_{ij} is provided by Hausman (1978, p. 1263) as follows:

$$m = \hat{q}' \hat{M}(\hat{q})^{-1}\hat{q} \tag{5}$$

where $\hat{q} = \hat{\beta}_{FE} - \hat{\beta}_{RE}$ is a k x 1 column vector of difference between fixed effects ($\hat{\beta}_{FE}$) and random effects ($\hat{\beta}_{RE}$) of parameter estimates (k), and $\hat{M}(\hat{q}) = V(\hat{\beta}_{FE}) - V(\hat{\beta}_{RE})$ is a k x k covariance matrix of difference between variances of $\hat{\beta}_{FE}$ and $\hat{\beta}_{RE}$. Equation 5 has a χ^2 distribution with k d.f. The calculated value (m = 695.85) exceeds $\chi^2_{29} = 49.5$ at the 1 percent level, rejecting the assumption of the error component model that U_{ij} and λ_t are orthogonal to the vector Z_{ijt}. Hence, the fixed effect model, called the covariance models, should be used in this analysis.

A Lagrange Multiplier test for heteroskedasticity developed by Breusch and Pagan (1979) and modified by White (1981) indicates that error terms do not have serious heteroskedasticity within cross-section units. The largest computed $nR^2 = 38.99$, which is less than $\chi^2_{29} = 49.59$ at the 1 percent significance level.

Countries included in the analysis are shown in Table 5. The time period considered is from 1981 to 1985. Countries engaged in sporadic trade were excluded from the analysis to retain data consistent over time and cross-section units (the pairs of trading countries). Financial data such as gross domestic products, exchange rates, international monetary reserves, gross domestic product deflator, and wholesale price indexes were taken from the International Monetary Fund's (IMF) International Financial Statistics.

TABLE 5. LIST OF COUNTRIES INCLUDED IN THE MEAT TRADE ANALYSIS

Exporting Countries	Importing Countries	Exporting/Importing Countries
Argentina	Egypt	Belgium
Australia	Greece	Canada
Austria	Japan	Germany
Brazil	Singapore	France
Denmark	Switzerland	Italy
Ireland		Netherlands
New Zealand		United Kingdom
Sweden		United States
Uruguay		
Yugoslavia		

Data on meat exports and imports were published in the United Nations and U.S. government documents in various issues. Export price data were computed by dividing each exporting country's total value of exports by the quantity exported. Import prices were computed by dividing the total value of imports by the quantity each country imported. Data on export promotion programs and trade restriction policies were obtained from Hillman (1978), Longworth (1984), Ojalla (1985), Patterson (1983), Simpson (1982), and USDA (1988, 1989).

Ocean freight rates are not available for all countries included in the analysis. An alternative is to estimate an ocean freight rate function with available sample rates for each year and use the function to estimate missing rates. This approach, however, did not provide superior results aside from the task of dealing with the errors in variable modelling. We, therefore, used distances as a proxy for transportation costs. Linnemann (1966), Roninen (1978), Bergstrand (1985, 1989), and Summary (1989) used distance as a proxy of transportation costs. The distances were calculated using oceanographic map published in The Times Atlas of Oceans, Time Book Limited.

Results

Model 1 in Table 6 is estimated by OLS. Models 2 and 3 are estimated by applying Least Squares techniques on variables expressed in deviation forms. [As explained in Hsiao (1986, p. 31), no dummy variables for individual country pairs and/or time effects are needed.] Model 1 is based on an assumption that all model coefficients are constant over time series and cross-section units, i.e., all effects of U_{ij} and λ_t are identically equal to zero. Model 2 is based on an assumption that time effects are identically zero. Finally, Model 3 is based on an assumption that trade effects vary over cross-section and time series units through intercept terms. Model 3 is the most efficient since the model does not include any constraints and is used for the analysis. The other models are presented for reference. Most estimated parameters have the expected signs and are statistically significant. All models have reasonable R^2s.

Effects of Distance, Income, Population, and Land

Linnemann (1966) termed variables such as distance, income, and population as geographical and demographic variables. As in traditional gravity models, distance, a natural barrier to trade, significantly impairs meat trade. Farm income represents the production capacity of red meat in exporting countries while gross domestic product is used to estimate consumers' purchasing power in an importing country. The estimated coefficient on the variable is positive as hypothesized and differ significantly from zero at the 5 percent level. This implies that a rise in exporting and/or importing country's income leads to increased trade flows. Likewise, increases in importing and exporting country's population will increase its consumption needs and production, respectively, increasing the total trade volume. The magnitude of the coefficients indicates that the quantities of meat traded are sensitive to neither the production capacity in exporting countries nor to disposable income in importing countries. The insensitivity in exporting countries can be attributed to excess production capacity and domestic livestock support programs in the countries. The insensitivity in importing countries is mainly because meat is imported largely on the basis of consumption need in most importing countries. The extent of the sensitivity, however, is greater in exporting countries than in importing countries.

The coefficient on importer's grazing land variable has a negative sign as expected and is significant at the 1 percent level. An increase in grazing land increases meat production and consequently decreases the volume of meat imports. The sign on the exporter's grazing land is converse. However, it is only marginally significant.

Effects of Prices, Exchange Rates, and Inflation

The estimated coefficients on import prices and export prices are negative and positive, respectively, as hypothesized. The corresponding t-values indicate that the coefficients on the export and import prices differ significantly from zero at the 1

TABLE 6. COVARIANCE MODEL ESTIMATES OF THE MEAT TRADE MODELS UNDER ALTERNATIVE ASSUMPTIONS ON SPECIFICATION OF TRADE EFFECTS (DEPENDENT VARIABLE: VOLUME OF MEAT TRADED)

Variable/coefficients	Model 1 All U_{ij} and λ_t are identically zero for all ij and t	Model 2 Only λ_t are zero for all t	Model 3 All U_{ij} and λ_t are different from zero
Distance (D)	0.3223(-3.58)****	-0.2459(-2.60)**	-0.2398(2.51)**
Demographic variables:			
Exporter's income (Y_i)	-0.1902(-3.44)****	0.2323(1.93)*	0.3675(1.68)*
Importer' s income (Y_j)	0.1549(3.57)****	0.1631(3.78)****	0.1442(3.39)****
Exporter's population (N_i)	0.6952(4.02)****	0.0871(0.68)	0.1469(1.15)
Importer's population (N_j)	0.2160(2.38)*	0.1332(1.65)	0.1591(1.99)*
Land variables:			
Exporter's grazing land (G_i)	-0.5050(4.48)****	-0.1705(1.67)	-0.1892(-1.86)*
Importer's grazing land (G_j)	-0.1549(-3.88)****	-0.1097(-2.70)**	-0.1083(-2.66)**
Price variables:			
Export price (P_i)	1.226(3.150)****	0.3855(1.20)	0.7245(1.98)*
Import price (P_j)	-0.146(-0.49)	-0.7117(-2.09)*	-0.7029(-2.06)*
Exporter's inflation (I_i)	0.3582(2.08)**	0.0633(0.52)	-0.2026(-1.18)
Importer's inflation (I_j)	-0.7235(-2.32)**	-0.9658(-2.56)**	-0.9884(-2.63)**
Exchange rate (E_{ij})	-0.0180(-0.55)	0.0125(0.26)	0.0248(0.51)
Economic union:			
Dummy for EC (ED)	1.991(6.55)****	1.9482(5.85)****	2.0153(6.09)****
Dummy for adjacency (AD)	1.593(6.02)****	1.7863(6.22)****	1.8090(6.35)****
Trade Policies:			
Long Term Agreement (LTA)	1.967(6.79)****	1.8371(5.70)****	1.9223(6.00)****
Quota (QUT)	-1.107(-4.43)****	-1.4172(-5.30)****	-1.4618(-5.22)****
Producer subsidy (PS)	-0.051(-0.21)	0.1966(1.640)	0.1791(1.48)
Consumer subsidy (CS)	0.091(1.96)*	-0.1721(20.34)****	-0.1636(16.64)****
H-and-m Disease (HMD)	-2.510(-9.38)****	-2.6972(-9.44)****	-2.6744(-9.43)****
Country Dummy Variable:			
Dummy for Argentina (DARG)	-3.696(-2.12)*	-2.990(-1.98)*	-1.9922(-1.78)*
Dummy for Australia (DAU)	0.0305(0.66)	-0.2272(0.47)	-0.4548(-0.94)
Dummy for Austria (DAT)	-4.507(-6.16)****	-4.6384(-6.88)****	-4.1576(-5.16)****
Dummy for Brazil (DBRA)	-3.297(-2.08)*	-0.0711(-0.15)	-0.5589(-1.09)
Dummy for Canada (DC)	-2.947(-6.32)****	-1.9493(-2.49)**	-2.7397(-4.97)****
Dummy for EEC (DEC)	-4.043(-6.72)****	-3.3393(-6.37)****	-2.9340(-4.97)****
Dummy for Sweden (DSE)	-4.320(-6.055)****	-3.4592(-5.40)****	-2.9471(-4.06)****
Dummy for Uruguay (DUR)	-2.365(-2.77)***	-1.5292(-3.17)****	-2.1556(-3.39)****
Dummy for US (DUS)	-1.028(-1.90)	-0.1976(-0.33)	-0.5221(-0.88)
Dummy for Yugoslavia (DYU)	-5.598(-9.27)****	-4.4906(-7.76)****	-3.9471(-6.16)****
Intercept	18.0490(8.51)****	---	---
R^2	0.501	---	---
Df	832	828	828
RMS	1.886	1.060	2.043

**** = Significant at 0.001 ** = Significant at 0.01
*** = Significant at 0.005 * = Significant at 0.05
Note: t-statistic in parentheses

percent level. The magnitude of the coefficient on exports is less than 1.0 in absolute value, implying that quantities of meat traded are not sensitive to export prices. The import price coefficient is also less than 1.0.

Exchange rates used in this analysis are defined as changes in the prices of importing countries' currencies in terms of exporting countries' currencies. The coefficient for the exchange rate variable is positive as hypothesized. An appreciation of an importing country's currency (a depreciation of an exporting country's currency) makes the exporting country's meat cheaper in the importing country's market and increases trade flow. However, the causal relation is not statistically significant at the 5 percent level.

Effects of Trade Promotion Programs and Restriction Policies

Specification tests indicate that export promotion programs and trade restriction policies should be included in the empirical model of meat trade. The export promotion program (LTA) has a positive sign as expected. The corresponding t-statistics indicate that the variable is significantly correlated to the quantities of meat traded at the 1 percent level. The magnitude of the coefficient suggests that the promotion program increases trade volume under bilateral trade agreements. Domestic subsidies given to producers in exporting countries do not significantly change trade flows of meat.

Some importing countries have used quotas to restrict meat imports to support their domestic livestock production. The variable has a negative sign, and its coefficient differs significantly from zero at the 1 percent level. This implies that quotas used by the importing countries reduced trade volume of meat imports. Other trade restricting variables, such as consumer subsidy equivalent variables and hoof-and-mouth disease, have negative signs as expected and differ significantly from zero at the 1 percent level. The size of estimated coefficients show that meat flows are not sensitive to the domestic consumer subsidy equivalent; they are, however, highly responsive to the quota system and inspection for hoof-and-mouth diseases.

We also introduced a dummy variable representing EC member countries. The results show that the European integration into a common market enhanced meat trade among the member countries. This supports the theory of welfare economics, which proves that economic integration increases welfare of the member countries through increases in trade volume among the countries. The estimated model shows that the EC significantly enhanced meat trade; the coefficient for the EC dummy variable is positive as expected and is highly correlated with the quantities of meat traded.

The estimated coefficient on the dummy variable representing the countries with a common border has a positive sign as expected and is statistically significant at the 1 percent level. This confirms that meat trade is more intense among border countries.

Dummy variables representing exporting countries differ significantly from zero, indicating that meat products are differentiated by country of origin. For example, Australia exports low-quality hamburger meat while the United States exports better-quality meat.

Conclusion And Policy Implications

A reduced form gravity model derived from a partial equilibrium model of world trade was applied to the world meat market to evaluate factors affecting meat trade flows. The gravity model was estimated by using a pooling technique for time series and cross-section data. Special attention was given to the impacts of meat export promotion and import restriction policies.

This study shows that the modified gravity model is applicable to single commodity trade flows. In the case of meat, the model provides statistical descriptions of meat flows and still retains the classical features of the conventional gravity models.

Income variables are important meat trade determinants. Given the inelastic demand in importing countries and inelastic supply in exporting countries, a sound growth in the world economy would stimulate world meat trade. As expected, the prices of meat in importing and exporting countries play an important role in determining the world trade flows. Strong competition among meat exporting countries makes export supply more sensitive to prices. The inelastic import demand simply reflects a unique aspect of food consumption that is not sensitive to prices.

Long-term agreements significantly increase international meat trade between individual partners. Hoof-and-mouth disease strongly impairs meat trade. On the import side, imposing quotas to restrict imports significantly reduces meat trade.

The formation of economic unions such as the EC stimulates meat trade among member countries. The findings also show that meat trade was intense among countries with a common border. This reflects the importance of distances among countries in the meat trade. For countries included in this analysis, we found that distances between exporting and importing countries are a major factor affecting meat trade.

Since distances between exporting and importing countries are a major factor affecting meat trade, it is natural to have more trade with neighboring countries. The U.S. and Canadian Free Trade Agreement will enhance trade flows of meat between these two countries. The North American Free Trade Agreement (NAFTA), which is under negotiation among the United States, Canada, and Mexico, will optimize trade flows among these three countries on the basis of the principle of comparative advantage and increase trade volume among these three countries.

A successful conclusion of the Uruguay Round of the GATT Negotiations would substantially reduce distortions to trade flows, and will increase trade volume of red meat among countries. However, distances and quality of meat may remain as major factors affecting trade flows.

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Appendix

The Commodity Specific Gravity Model

The derivation of the single commodity gravity model follows the procedure indicated in trade literature. According to Linnemann (1966) and more recently Bergstrand (1985, 1989), a gravity model is a reduced form equation from the general equilibrium of demand and supply systems.

Specification of the Supply Model

The supply model is derived from the firms' profit maximization procedure in exporting countries. Firms are assumed to produce the specified commodity for exports in each exporting country. The producing firms in country i maximize the following total profit functions:

$$\text{(A1)} \quad \pi = \sum_{k=1}^{N} P_{ik}X_{ik} - W_iR_i \qquad i=1, \ldots N$$

where P_{ik} is the export price of i's commodity paid by importing country k, X_{ik} is the amount of i's commodity imported by country k, W_i is the i-currency value of a unit R_i, and R_i is the single resource input used in the production of the commodity in country i. R_i in each country is allocated according to the constant elasticity of transformation (CET) production referred to as

$$\text{(A2)} \quad R_i = \left(\sum_{\substack{k=1 \\ k \neq i}}^{N} X_{ik}^{\phi_i} \right)^{1/\phi_i} \qquad i=1, \ldots, N$$

where $\phi_i = (1 + \gamma_i)/\gamma_i$ and γ_i is i's CET production among export markets $(0 \leq \gamma_i \leq \bowtie)$.

In producing countries income is assumed to be a limiting factor in producing the commodity so the $Y_i = W_i R_i$, where Y_i is the allocated income. Substituting Equation (A2) into (A1) and maximizing the resulting profit functions yield, after using $Y_i = W_iR_i$ and some algebra, the desired export supply equation is:

$$\text{(A3)} \quad X_{ij}^{s} = Y_i P_{ij}^{\gamma_j} \left(\sum_{k=1}^{N} P_{ik}^{1+\gamma_i} \right)^{1/(1-\gamma_i)}$$

where X_{ij}^{s} is the quantity of i's commodity shipped to country j.

Specification of the Import Demand Functions

Consumer theory is used to derive import demand functions. Assume that individuals in every importing country j, each year, maximize the same constant elasticity of substitution (CES) utility function:

$$\text{(A4)} \quad U_j = \left(\sum_{\substack{k=1 \\ k \neq j}}^{N_1} X_{kj}^{\theta_j} \right)^{1/\theta_j} \qquad j=1,2, \ldots M$$

where X_{kj} is the quantity of the commodity imported from country k, i.e., net exports from k to j. The single commodity is assumed to be differentiated by country of origin so that in the exponent $\theta_j = (\sigma_j - 1)/\sigma_j$, where σ_j is the CES among imports. Consumption expenditures are limited by the income constraints as

$$\text{(A5)} \qquad y_j = \sum_{k=1}^{N_j} \overline{P}_{kj} X_{kj} \text{ where } \overline{P}_{kj} = P_{kj} T_{kj} C_{kj} / E_{kj}$$

where P_{kj} is the unit price of k's commodity sold in j's market, T_{kj} is 1 + t_{kj} where t_{kj} is import tariff rates on j's imports; C_{kj} is the transport cost factor (c.i.f. or f.o.b.) to ship k's commodity to country j and E_{kj} is the spot exchange rate of j's currency in term of k' currency.

Equation (A4) is maximized subject to Equation (A5) by forming an augmented Lagrangian function. The maximization procedure generates the desired import demand equations as:

$$\text{(A6)} \qquad X_{ij}^{d} = Y_j P_{ij}^{-\sigma_j} T_{ij}^{-\sigma_j} C_{ij}^{-\sigma_j} E_{ij}^{-\sigma_j} \left(\sum_{k=1}^{N_j} \overline{P}_{ij}^{1-\sigma_j} \right)^{-1}$$

where X_{ij}^{d} is the quantity of i's commodity sold in country j and other variables have been previously defined.

A Commodity Specific Gravity Model

Using the market general equilibrium conditions,

$$\text{(A7)} \quad X_{ij}^{d} = X_{ij}^{s} = X_{ij}$$

where X_{ij} is the equilibrium or actual quantity traded from i to j, the gravity equation is easily derived as follows:

$$\text{(A8)} \quad X_{ij} = Y_i^{\frac{\gamma_i}{\sigma_j+\gamma_i}} Y_j^{\frac{\sigma_j}{\sigma_j+\gamma_i}} T_{ij}^{-\frac{\gamma_i\sigma_j}{\sigma_j+\gamma_i}} C_{ij}^{\frac{\gamma_i\sigma_j}{\sigma_j+\gamma_i}} E_{ij}^{\frac{\gamma_i\sigma_j}{\sigma_j+\gamma_i}} \left(\sum_{\substack{k=1 \\ k \neq i}}^{N} P_{ik}^{1+\gamma_i} \right)^{-\frac{\sigma_j}{\sigma_j+\gamma_i}} \left(\sum_{\substack{k=1 \\ k \neq j}}^{N_j} \overline{P}_{kj}^{1-\sigma_j} \right)^{-\frac{\gamma_i}{\sigma_j+\gamma_i}}$$

i = 1, ...N and j=1, ..., M