ELSEVIER

Agricultural Economics 14 (1996) 201-212

AGRICULTURAL ECONOMICS

Assessing the effects of tariff reform on U.S. food manufacturing industries: the role of imperfect competition and intermediate inputs

D. Kent Lanclos [a,*], Thomas W. Hertel [b], Stephen Devadoss [a]

[a] Department of Agricultural Economics and Rural Sociology, University of Idaho, Moscow, ID, USA
[b] Department of Agricultural Economics, Purdue University, West Lafayette, IN, USA

Accepted 22 February 1996

Abstract

Recent work indicates that the joint effects of intermediate input and final output tariff reforms on equilibrium in the differentiated final products sector are analytically ambiguous. This issue is addressed empirically for disaggregate, imperfectly competitive U.S. food manufacturing industries. The input tariff effect dominates in most industries, leading to increases in the number of U.S. firms and total industry output as a result of tariff reform. This provides evidence that the existing U.S. tariff profile discriminates against domestic food manufacturers, as input tariff effects outweigh the protection offered by output tariffs. This conclusion is robust to changes in the degree of interfirm rivalry (monopolistic competition or cournot oligopoly).

1. Introduction

Processed foods now account for over half of the total value of world trade in farm and food products. In 1990, for example, processed foods accounted for $171 billion or 55 percent of world trade value in such products. In comparison, bulk unprocessed agricultural commodities (e.g., corn, soybeans) accounted for only 18 percent (MacDonald and Lee, 1992). Also, processed foods are the most rapidly growing share of world trade in farm and food products. [1] However, the U.S. share of this trade has been in decline since the late 1970s, raising concerns about the competitive position of U.S. food manufacturers in this large and growing market (NC-194, 1988, MacDonald and Lee, 1992).

Unfortunately, there has been a dearth of research into the international dimensions of food processing activity. Attention has instead been focused on trade in bulk agricultural commodities, or the structure, conduct and performance (SCP) of domestic food manufacturing industries and distribution channels. Furthermore, little effort has been expended to assess the qualitative and quantitative effects of trade policies on the food manufacturing sector. This neglect is particularly puzzling in light of recent trade liberalization efforts (e.g., NAFTA and GATT's Uruguay Round) which are likely to spur increased growth in processed foods trade.

The objective of this study is to examine the

* Corresponding author.

[1] Throughout the paper, the term farm products is used to refer to bulk agricultural commodities and the term food products refers to processed commodities.

PII S0169-5150(96)01189-9

effects of tariff reform on disaggregate U.S. food manufacturing industries.[2] Two characteristics of the food manufacturing sector are critical for such policy analysis. First, many food manufacturing industries are imperfectly competitive. In particular, these industries exhibit high levels of advertising and product differentiation (Connor et al., 1985). In the United States, for example, advertising by food manufacturers accounts for roughly 32 percent of advertising by all manufacturers. Yet, manufactured food products account for only 12 percent of total manufactured goods sales (Sutton, 1991). In addition, high levels of advertising have been associated with the high levels of product differentiation in food processing (Schmalensee, 1978, Padberg and Westgren, 1979). This suggests that recent developments in the imperfectly competitive trade literature may provide an appropriate vehicle for analyzing the effects of tariff reform on food processing activity.

Second, intermediate farm and food inputs account for a significant proportion of the variable costs of production in the food manufacturing sector. In the United States, for example, the aggregate cost share of farm and food inputs exceeds 50 percent in many industries (Table 1). Also, many of these intermediate farm and food inputs are heavily traded and are subject to high levels of protection. Hence, a reduction in input protection may lead to significant changes in the costs of production in food manufacturing. In turn, this could affect the profitability and distribution of food processing activity across countries. Consequently, understanding the implications for food processing activity may provide an important piece of the puzzle when evaluating the effects of agricultural trade reforms.

In this study, tariff reforms in the markets for intermediate farm and food inputs and differentiated consumer food products are examined. There exists a substantial body of literature in which the effects of trade policies in differentiated final product markets have been analyzed (e.g., Brander and Spencer, 1984, Brown, 1991). Recent theoretical work by Lanclos and Hertel (1995), however, has highlighted the potential importance of trade policies directed towards intermediate inputs on equilibrium in the differentiated final products sector. In particular, input tariff reform serves to reduce the marginal cost of production in the domestic processing activity, increasing the competitiveness of domestic manufacturers relative to foreign rivals. Output tariff reform, however, increases the relative competitiveness of foreign manufacturers. As a result, the effects of joint tariff reforms in the intermediate input and final product markets are analytically ambiguous. Also, Lanclos and Hertel (1995) found that the presence of imperfect competition in the final products sector can generate results which diverge from those obtained under the perfectly competitive paradigm. In this study, an empirical assessment of the effects of intermediate input and final output tariff reforms on disaggregate, imperfectly competitive U.S. food manufacturing industries is presented. We find that the existing U.S. tariff profile discriminates against domestic food manufacturers. In particular, though U.S. food manufacturers are protected in the output market, tariffs on purchased inputs have a greater effect on equilibrium in the food manufacturing sector. Thus, their joint elimination results in an expansion of food manufacturing activity.

2. Theoretical framework

The model used in this study builds on recent analytical work by Lanclos and Hertel (1995). In this application, there are two countries—the United States (u) and an aggregate rest of world (r). To permit application to disaggregate food manufacturing industries, partial equilibrium assumptions are employed. These assumptions are that aggregate consumer expenditure, primary factor prices and nonfood prices are fixed exogenously in each country. Also, integrated markets and zero transport costs are assumed such that prices are equal in both markets in the absence of policy distortions.

Consumer preferences for differentiated food products in each country are represented by a CES

[2] Non-tariff barriers (NTB's) are also used extensively to protect domestic producers of farm and food products. While NTB's are not considered in this analysis, we note that the principle of tariffication of NTB's has been adopted in the recent Uruguay Round GATT agreement.

sub-utility function [3] defined over domestic and imported varieties in each industry. [4] These preferences are asymmetric such that consumers in each country display a preference for domestic varieties. Hence, domestic and foreign varieties have different weights in each country's sub-utility function (Venables, 1987). The resulting CES sub-utility function for country j is written as

$$Y_j = \left[N_i(a_{ij}Y_{ij})^{(\sigma-1)/\sigma} + N_j(a_{jj}Y_{jj})^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)},$$
$$i,j = u,r, i \neq j, \tag{1}$$

where $\sigma \geq 1$, Y_j is the CES composite of differentiated food products consumed in country j, N_j is the number of symmetric food manufacturing firms located in country j, Y_{ij} is the quantity of sales of a representative country i firm to consumers in country j, and a_{ij} is a parameter which captures the preferences of country j consumers for differentiated food products produced in country i. Dual to the sub-utility function is the CES price index (or unit expenditure function) which is

$$P_j = \left[N_i(P_{ij}/a_{ij})^{1-\sigma} + N_j(P_{jj}/a_{jj})^{1-\sigma} \right]^{1/(1-\sigma)}, \tag{2}$$

where P_j is unit expenditure in country j and P_{ij} is the price charged by a country i firm in country j.

Defining M_j as aggregate consumer expenditure in country j, demand for the differentiated food products composite is given by

$$P_jY_j = \Psi_j(P_j)M_j, \tag{3}$$

where $\Psi_j(P_j)$ is the share of consumer expenditure spent on differentiated food products by country j consumers. Demand for the output of a country i firm in country j (Y_{ij}) is then given by

$$Y_{ij} = P_{ij}^{-\sigma} a_{ij}^{\sigma-1} P_j^{\sigma} Y_j. \tag{4}$$

Turning to the supply side of the model, differentiated food products are produced by a *monopolistically competitive* industry in each country. The production technology for differentiated food products is CES, combining primary factors and intermediate inputs in variable proportions according to the industry's elasticity of substitution among inputs. The actual production technology is constant returns to scale. In order to enter and remain in the market, however, a firm must pay a fixed (and recurrent) entry fee comprised entirely of primary factors. Hence, firms operate under conditions of declining average total cost due to the presence of fixed entry costs. In addition, each firm produces a single differentiated product.

The profits of a representative firm in country i (π_i) may be written as

$$\pi_i = Y_{ii}P_{ii} - C_i + Y_{ij}P_{ij} - C_i(T_{ij}) - G_i, \tag{5}$$

where C_i is the (constant) marginal cost of production, T_{ij} is one plus the ad valorem output tariff (i.e., the power of the ad valorem output tariff) faced by a firm located in country i and selling in country j and G_i is the fixed cost of entry into the market. With primary factor prices fixed by assumption, the marginal cost function is written solely as a function of the intermediate inputs:

$$C_i = C_i(W_i^1, W_i^2, \ldots, W_i^k), \tag{6}$$

where W_i^k is the price of the kth intermediate input in country i. The price linkage equation for the kth intermediate input in country i is

$$W_i^k = W_j^k(T_{ji}^k) \tag{7}$$

where T_{ji}^k is one plus the ad valorem tariff (i.e., the power of the ad valorem tariff) imposed by country i on imports of the kth intermediate input from country j. These intermediate inputs are produced under conditions of perfect competition in each country.

The first order conditions for profit maximization of (Eq. (5)) subject to the demand equations (Eq. (4)) are given by

$$P_{ii}(1 - 1/\xi_i) = C_i \tag{8}$$
$$P_{ij}(1 - 1/\xi_i) = C_i(T_{ij})$$

[3] The CES formulation of preferences for products differentiated at the firm-level has received widespread use. Its appeal is that it is compatible with aggregation over heterogeneous consumers (e.g., Anderson et al., 1989) A primary criticism of the CES approach is that it places perhaps undue weight on gains from greater variety. Another common approach to endogenous product differentiation is the spatial, or unit-circle, approach in which the gains from additional variety fall much more quickly (e.g., Salop, 1979). The most appropriate preference structure for individual industries is a question for empirical analysis and is not addressed in this paper.

[4] For ease of exposition, the analytical framework is developed with respect to a single food manufacturing industry. In the empirical application, an analogous set of equations characterizes equilibrium in each food manufacturing industry.

where $\xi_i \geq 1$ is the aggregate perceived demand elasticity maintained by a representative firm located in country i. Under the hypothesis of monopolistic competition, the aggregate perceived demand elasticity and the elasticity of substitution among differentiated products are approximately equal, hence, $\xi_i = \sigma$.

Table 1
SIC code, industry definition, markup, aggregate cost share of intermediate farm and food inputs, cost share weighted input tariff and final output tariff for U.S. food industries

SIC code	Industry definition	Markup of U.S. firms	Agg. input cost share	Share weighted input tariff	Final output tariff
2011	Meat packing plants (Meat)	1.05	0.82	0.76	2.23
2013	Sausages (Sausage)	1.13	0.53	1.29	2.89
2016	Poultry dressing plants (Poultry)	1.09	0.70	2.81	8.48
2017	Poultry and egg processing (Egg)	1.09	0.53	3.59	9.01
2021	Creamery butter (Butter)	1.05	0.91	5.65	12.47
2022	Cheese, natural and processed (Cheese)	1.13	0.75	2.98	13.19
2023	Condensed and evap. milk (ConMilk)	1.30	0.53	1.69	7.30
2024	Ice cream and frozen desserts (IceCream)	1.15	0.51	4.08	20.00
2026	Fluid milk (FluMilk)	1.14	0.68	1.37	8.39
2091	Canned and cured seafoods (CanSea)	1.19	0.02	0.16	2.50
2032	Canned specialities (CanSpec)	1.35	0.18	1.44	7.00
2033	Canned fruits and vegetables (CanFV)	1.31	0.23	2.14	10.40
2034	Dehydrated food products (Dehydrate)	1.33	0.31	2.67	7.86
2035	Pickles, sauces and salad dress (Dress)	1.35	0.21	2.34	8.64
2092	Fresh or frozen packaged fish (FrozFish)	1.14	0.08	0.34	0.00
2037	Frozen fruits and vegetables (FrozFV)	1.27	0.27	2.36	10.89
2038	Frozen specialties (FrozSpec)	1.31	0.32	2.67	0.00
2041	Flour and oth grain mill prod (GrainMill)	1.16	0.53	2.10	6.04
2043	Cereal breakfast foods (Cereal)	1.58	0.15	1.47	2.50
2045	Blended and prepared flour (Flour)	1.34	0.34	3.77	0.00
2046	Wet corn milling (WetCorn)	1.30	0.38	3.90	4.44
2047	Pet foods (Pet)	1.44	0.19	1.18	10.00
2048	Other prepared feeds (Feed)	1.14	0.66	3.96	2.32
2044	Rice milling (RiceMill)	1.21	0.52	1.88	1.75
2051	Bread, cake and related products (Bread)	1.34	0.14	1.05	1.67
2052	Cookies and crackers (Cookie)	1.41	0.17	1.89	0.00
2061	Sugar (Sugar)	1.05	0.59	11.83	26.02
2065	Confectionary products (Confect)	1.35	0.36	3.10	10.45
2066	Chocolate and cocoa products (Cocoa)	1.34	0.25	2.77	2.04
2067	Chewing gum (Gum)	1.51	0.19	1.64	0.00
2082	Malt beverages (MaltBev)	1.45	0.08	0.26	5.10
2083	Malt (Malt)	1.17	0.43	0.95	1.95
2084	Wines, brandy and brandy spirits (Wine)	1.26	0.22	1.35	7.06
2085	Distilled liquor, except brandy (Liquor)	1.46	0.08	0.03	0.00
2086	Bottled and canned soft drinks (Drinks)	1.23	0.19	2.50	0.45
2087	Oth flavoring extracts and syrups (Extracts)	1.63	0.25	3.37	11.51
2074	Cottonseed oil mills (CotMill)	1.05	0.57	0.99	12.25
2075	Soybean oil mills (SoyMill)	1.07	0.77	3.14	13.23
2076	Other vegetable oil mills (VegMill)	1.10	0.40	1.42	4.32
2077	Animal and marine fats and oils (AniOil)	1.23	0.37	1.50	4.12
2095	Roasted coffee (Coffee)	1.33	0.00	0.00	0.10
2079	Shortening and cooking oils (Short)	1.21	0.58	6.45	12.35
2097	Manufactured ice (Ice)	1.33	0.00	0.00	0.00
2098	Macaroni and spaghetti (Macaroni)	1.52	0.24	1.45	0.00
2099	Other food preparations (OthFood)	1.57	0.15	1.37	5.09

The optimal markup expression for a representative country i firm is

$$MK_i = P_{ii}/C_i. \tag{9}$$

where $MK_i = (1 - 1/\xi_i)^{-1}$. Under the hypothesis of monopolistic competition, the number of firms is sufficiently large such that we can ignore strategic interactions among the firms. Hence, markups are constant which implies that perceived demand elasticities are also constant.

In order to complete the model, we define the following "share-like" parameters: [5]

$$S_{ii} = (P_{ii}/a_{ii})^{1-\sigma} = C_i\sigma/\left[a_{ii}(\sigma-1)\right]^{1-\sigma}, \tag{10}$$
$$S_{ij} = (P_{ij}/a_{ij})^{1-\sigma} = C_i(T_{ij})\sigma/\left[a_{ij}(\sigma-1)\right)^{1-\sigma},$$

The right hand sides of (Eq. (10)) follow from the first order conditions for profit maximization. Also, under the assumption of asymmetric preferences (i.e., consumers exhibit a preference for domestic varieties), it follows that

$$S_{ij}/S_{jj} < S_{ii}/S_{ji}. \tag{11}$$

Thus, a representative firm has a larger share of its domestic market than it has in the foreign market ($S_{ii} \geq S_{ij}$). Further, the share of a firm in its domestic market exceeds that of a foreign firm in the domestic market ($S_{ii} \geq S_{ji}$).

Free entry and exit of firms assures a zero profits equilibrium. Denoting the maximized profits of a representative firm in country i as Π_i^*, the profit function may be expressed in terms of the share parameters and price indices as

$$\Pi_i^* = \left\{\left[S_{ii}P_i^{\sigma-1}\Psi_i(P_i)M_i + S_{ij}P_j^{\sigma-1}\Psi_j(P_j)M_j\right]/\sigma\right\} - G_i = 0. \tag{12}$$

The number of firms active in country j can be found by simultaneously solving (Eq. (2)), noting that $S_{ij} = (P_{ij}/a_{ij})^{1-\sigma}$ by (Eq. (10)). This gives

$$N_j = \left(S_{ii}P_j^{1-\sigma} + S_{ij}P_i^{1-\sigma}\right)/\Delta, \tag{13}$$

where Δ is the determinant of the 2×2 share matrix with representative element S_{ij}. From (Eq. (11)), $\Delta \geq 0$.

[5] While it is tempting to interpret the S_{ij}'s as a representative firm's actual market shares, this is only true in the special case in which all unit expenditures are equal to one (i.e., the actual market share, λ_{ij}, is given by $P_{ij}Y_{ij}/P_jY_j$).

Output per firm is obtained as follows. Given that price is a markup over marginal cost and the markup is equal to $(1 - 1/\xi_i)^{-1}$, then $(1 - 1/\xi_i)$ of per firm revenue covers operating costs. Thus, $1/\xi_i$ of per firm revenue must cover fixed costs in a zero profits equilibrium. As a result, per firm revenue is $\xi_i G_i$. Dividing this expression by a representative firm's price, output per firm is

$$Q_i^{\mathrm{f}} = \xi_i G_i/P_{ii}. \tag{14}$$

The final variable of interest, total industry output, is simply obtained as the product of output per firm and the number of active firms in country i:

$$Q_i = N_i Q_i^{\mathrm{f}}. \tag{15}$$

2.1. Analytical results

Generalized analytical solutions for this model are developed in Lanclos and Hertel (1995). Key results are summarized below in order to motivate the empirical analysis which follows. These analytical results have been specialized to be consistent with the empirical analysis. In particular, the U.S. is assumed to undertake unilateral tariff reform in the markets for intermediate farm and food inputs and differentiated food products. Also, the U.S. is small on the import side such that the world prices of intermediate farm and food inputs are unaffected by the U.S. policy actions. [6] Finally, we focus largely on implications for the U.S. food manufacturing sector.

Proportional changes in variables are denoted using lower-case. From (Eqs. (6) and (9)), the proportional change in a representative U.S. firm's price is given by

$$p_{\mathrm{uu}} = MK_{\mathrm{u}}\Sigma_{\mathrm{k}}\Omega_{\mathrm{u}}^{\mathrm{k}}\, t_{\mathrm{ru}}^{\mathrm{k}}, \tag{16}$$

where $\Omega_{\mathrm{u}}^{\mathrm{k}}$ is the cost share of the kth intermediate input and $t_{\mathrm{ru}}^{\mathrm{k}}$ is the proportional change in the power of the ad valorem tariff on the kth intermediate input (i.e., $t_{\mathrm{ru}}^{\mathrm{k}} = \mathrm{d}T_{\mathrm{ru}}^{\mathrm{k}}/T_{\mathrm{ru}}^{\mathrm{k}}$). [7] Note that prices charged by

[6] Assuming the U.S. to be a small country in the intermediate farm and food input markets may be a concern to some readers. However, this assumption greatly reduces data collection and computational efforts. Also relaxing this assumption will not materially effect the qualitative implications of the study.

[7] $\mathrm{MK_u}$ appears in (Eqn. 16) to scale total cost shares to shares in variable costs, which determine marginal behavior.

U.S. firms depend only on changes in marginal costs —they are not affected by tariff reform in the output market. As a result, a representative U.S. firm's price unambiguously decreases in response to intermediate input tariff reforms. The proportional change in a representative ROW firm's price in the U.S. market is given by

$$p_{\mathrm{ru}} = t_{\mathrm{ru}} = \alpha \sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} t_{\mathrm{ru}}^{\mathrm{k}}, \tag{17}$$

where t_{ru} is the proportional change in the U.S. output tariff on differentiated food products. Thus, the price charged by a representative ROW firm in the U.S. market also decreases. Note, however, that the price charged by an ROW firm in its domestic market (P_{rr}) is unchanged by U.S. tariff reforms since its marginal cost of production is unaffected.

The right hand side of (Eq. (17)) bears further discussion. Tariff escalation characterizes the tariff profile of many countries, including the U.S. (Yates, 1959, Yeats, 1988). For expositional convenience, the degree of tariff escalation between the average (cost share weighted) intermediate input tariff ($\Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} t_{\mathrm{ru}}^{\mathrm{k}}$) and the final output tariff (t_{ru}) is parameterized by α. When $\alpha = 1$, the final output and average intermediate input tariffs are equal, and hence, there is no tariff escalation. When $\alpha \geq 1$, however, the final output tariff exceeds the average input tariff and tariffs are said to be escalating.

From (Eq. (14)), the proportional change in output per U.S. firm is obtained by

$$q_{\mathrm{u}}^{\mathrm{f}} = -p_{\mathrm{uu}} = -MK_{\mathrm{u}} \Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} t_{\mathrm{ru}}^{\mathrm{k}}. \tag{18}$$

Hence, output per U.S. firm unambiguously increases in response to tariff reform in the intermediate input markets. Note from (Eq. (18)) that tariff reform in the output market does not affect output per U.S. firm since it is equal to the negative of the change in price.

Eq. (12) is solved simultaneously for the U.S. and ROW to determine the proportional changes in unit expenditure in each country. This results in the following expressions for p_{u} and p_{r}:

$$p_{\mathrm{u}} = \frac{-S_{\mathrm{rr}} \gamma_{\mathrm{u}} MK_{\mathrm{u}} \Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} + S_{\mathrm{ur}} \gamma_{\mathrm{r}} \alpha \Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} (1-\sigma) t_{\mathrm{ru}}^{\mathrm{k}}}{\Delta(\sigma - \eta_{\mathrm{u}}) \Psi_{\mathrm{u}}(P_{\mathrm{u}}) M_{\mathrm{u}} P_{\mathrm{u}}^{\sigma-1}} \tag{19}$$

$$p_{\mathrm{r}} = \frac{S_{\mathrm{ru}} \gamma_{\mathrm{u}} MK_{\mathrm{u}} \Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} - S_{\mathrm{uu}} \gamma_{\mathrm{r}} \alpha \Sigma_{\mathrm{k}} \Omega_{\mathrm{u}}^{\mathrm{k}} (1-\sigma) t_{\mathrm{ru}}^{\mathrm{k}}}{\Delta(\sigma - \eta_{\mathrm{r}}) \Psi_{\mathrm{r}}(P_{\mathrm{r}}) M_{\mathrm{r}} P_{\mathrm{r}}^{\sigma-1}}$$

where γ_{u} (equals $S_{\mathrm{uu}}\ P_{\mathrm{u}}^{\sigma-1}\ \Psi_{\mathrm{u}}(P_{\mathrm{u}})M_{\mathrm{u}} + S_{\mathrm{ur}}\ P_{\mathrm{r}}^{\sigma-1}\ \Psi_{\mathrm{r}}(P_{\mathrm{r}})M_{\mathrm{r}}$), and γ_{r} (equals $S_{\mathrm{ru}}\ P_{\mathrm{u}}^{\sigma-1}\ \Psi_{\mathrm{u}}(P_{\mathrm{u}})M_{\mathrm{u}}$) are share weighted income terms for the U.S. and ROW, respectively, and η_i is the elasticity of demand for Y_i with respect to P_i. The signs of both p_{u} and p_{r} are indeterminate. The denominator of each expression is clearly positive. The ambiguity arises in their numerators. Tariff reform in the input markets (captured by $\gamma_{\mathrm{u}}\ MK_{\mathrm{u}}\ \Sigma_{\mathrm{k}}\ \Omega_{\mathrm{u}}^{\mathrm{k}}$) serves to decrease (increase) unit expenditure in the U.S. (ROW). Tariff reform in the output market (captured by $\gamma_{\mathrm{r}}\ \alpha\ \Sigma_{\mathrm{k}}\ \Omega_{\mathrm{u}}^{\mathrm{k}}$), however, serves to increase (decrease) unit expenditure in the U.S. (ROW). This ambiguity in unit expenditures also implies ambiguity for the proportional change in the number of U.S. firms. This can be seen from log-differentiating (Eq. (13)):

$$n_{\mathrm{u}} = \frac{(1-\sigma) S_{\mathrm{rr}} P_{\mathrm{u}}^{1-\sigma} p_{\mathrm{u}} + S_{\mathrm{rr}} P_{\mathrm{u}}^{1-\sigma} s_{\mathrm{rr}} - (1-\sigma) S_{\mathrm{ru}} P_{\mathrm{r}}^{1-\sigma} p_{\mathrm{r}} - S_{\mathrm{ru}} P_{\mathrm{r}}^{1-\sigma} s_{\mathrm{ru}}}{N_{\mathrm{u}} \Delta}. \tag{20}$$

Given that the signs of p_{u} and p_{r} are ambiguous, the proportional change in the number of U.S. firms is also ambiguous. As pointed out by Lanclos and Hertel (1995), the overall effect on unit expenditures and the number of firms depends on parameters whose magnitudes must be empirically determined. In particular, the degree of tariff escalation is critical.

As tariff escalation increases, output tariff effects become more likely to dominate input tariff effects and thereby lead to an increase (decrease) in U.S. (ROW) unit expenditure. Output market tariff reform also results in an increase in the competitiveness of ROW firms relative to U.S. manufacturers. As a result, U.S. firms incur negative profits and exit of U.S. firms is required to restore market equilibrium. However, it is possible for input tariff effects to *dominate* output tariff effects if the degree of tariff escalation is not too great. In this case, U.S. (ROW) unit expenditure will decline (increase) after the joint tariff reforms. Also, tariff reform in the intermediate input markets lowers the costs of production for U.S. firms, generating excess profits and spurring domestic entry. Given the prevalence of U.S. policy interventions in the markets for intermediate farm and food inputs, the latter case is a plausible result of tariff reform.

Finally, the proportional change in total output in the U.S. is also ambiguous, which can be seen from log-differentiating (Eq. (15)):

$$q_u = q_u^f + n_u. \quad (21)$$

For the U.S., the change in output per firm is unambiguously positive. However, the change in the number of U.S. firms is indeterminate; hence, the proportional change in total industry output is also indeterminate.

2.2. Cournot oligopoly

The analysis conducted thus far has been based on the assumption of monopolistic competition, which is questionable in some of the food manufacturing industries because of their highly concentrated, oligopolistic nature. In order to determine if our results are robust to changes in the degree of inter-firm rivalry, we also consider a scenario in which food manufacturers are hypothesized to engage in Cournot oligopolistic behavior. When industries are oligopolistic, strategic interactions between rivals

Table 2
Percentage changes in prices, output per firm, the number of firms and total output resulting from intermediate input and final output tariff reforms in U.S. food manufacturing industries under monopolistic competition

Industry [a]	U.S. price	Output per U.S. firm	Number of U.S. firms	Total U.S. output
Sausage	−1.42	1.42	11.11	11.82
Cheese	−3.11	3.11	14.33	18.00
ConMilk	−2.05	2.05	5.13	7.33
IceCream	−4.29	4.29	25.72	31.36
FluMilk	−1.46	1.46	9.46	11.08
CanSea	−0.18	0.18	0.64	0.81
CanSpec	−1.83	1.83	3.77	5.71
CanFV	−2.62	2.62	−18.31	−16.11
Dehydrate	−3.33	3.33	11.95	15.81
FrozFish	−0.37	0.37	2.33	2.71
FrozFV	−2.77	2.77	4.95	7.94
FrozSpec	−3.19	3.19	10.47	11.90
GrainMill	−2.32	2.32	10.59	13.22
Cereal	−2.04	2.04	2.53	4.67
Flour	−4.42	4.42	10.17	15.27
RiceMill	−2.21	2.21	11.98	14.50
WetCorn	−1.32	1.32	2.41	3.78
Bread	−1.29	1.29	3.01	4.35
Cookie	−2.35	2.35	4.41	6.93
Confect	−3.74	3.74	6.77	10.92
Cocoa	−3.22	3.22	8.97	12.59
Gum	−2.17	2.17	3.09	5.37
MaltBev	−0.35	0.35	−0.78	−0.44
Malt	−1.09	1.09	5.93	7.09
Wine	−1.62	1.62	−3.80	−2.22
Liquor	−0.04	0.04	0.07	0.11
Drinks	−2.72	2.72	10.34	13.42
Extracts	−4.77	4.77	5.37	10.65
Coffee	0.00	0.00	0.01	0.01
Short	−7.00	7.00	29.48	39.23
Ice	0.00	0.00	0.00	0.00
Macaroni	−2.09	2.09	3.50	5.71
OthFood	−1.93	1.93	2.02	4.02

[a] See Table 1 for the correspondence between industry abbreviations and definitions.

must be considered because of the limited number of firms in the marketplace. As a result, markups are variable in oligopolistic industries. This gives rise to a potential "procompetitive" effect of tariff reform. The procompetitive effect of tariff reform is defined as a reduction in firms' optimal markups due to increased competition in the marketplace, reflecting the reduction in monopoly power (Vousden, 1990). This reduction in markups has also been associated with an increase in output per firm as the lower markup induces firms to move to a lower point along their average cost curve (e.g., Markusen, 1981, Devarajan and Rodrik, 1991).

Because markups are variable, perceived demand elasticities must also be variable, i.e., $MK_i = (1 - 1/\xi_i)^{-1}$. Under the integrated markets assumption, a firm's aggregate perceived demand elasticity (ξ_i) is a quantity weighted average of the perceived demand elasticities in each of the individual markets (ξ_{ij}):

$$\xi_i = \Phi_{ii}\xi_{ii} + \Phi_{ij}\xi_{ij} \qquad (22)$$

where Φ_{ij} is the share of output produced in country i which is sold in country j.

The manner in which these market specific perceived demand elasticities are formed depends on the nature of the static, noncooperative game played. Under the Cournot assumption, firms takes their rivals quantities as given when determining their optimal markups. This results in the following Cournot based perceived demand elasticity in each market (Hertel, 1994):

$$\xi_{ij} = \sigma/\left[1 + (\sigma - 1)(\Theta_{ij}/N_i)\right] \qquad (23)$$

where Θ_{ij} is the share of total consumption of differentiated products in country j supplied by country i firms. The remainder of the Cournot model is analogous to the monopolistic competition model, with the exception that $mk_u \neq 0$.

3. Empirical results

As noted above, traded intermediate farm and food products are an important component of variable costs in many food processing industries. Yet, the cost structure effects of trade policies affecting these intermediate inputs have largely been ignored in the literature. Given the large cost share of intermediate farm and food inputs in many U.S. food manufacturing industries, this issue is particularly relevant to the analysis of tariff reforms in the U.S. food processing sector. Because this is a model of final consumer demand, industries which produce primarily for intermediate input use or non-human consumption (e.g., feeds) are excluded from the analysis. Also, industries in which the initial markups are 10 percent or less are excluded because these low markups are not suggestive of monopoly power in these industries. This results in 33 industries which are cast as monopolistically competitive, consumer goods industries and are listed in Table 2. Finally, tariff reform is defined as complete elimination of tariffs in all experiments.

3.1. Monopolistic competition

In Table 2, the effects of joint intermediate input and output tariff reforms on monopolistically competitive U.S. food manufacturing industries are reported.[8] Under monopolistic competition, the proportional change in a representative U.S. firm's price is simply equal to the proportional change in the marginal cost of production, given that markups are exogenous (Eq. (16)).[9] Also, the change in output per U.S. firm is simply equal to the negative of the price change (Eq. (18)). The price charged by a representative U.S. firm decreases in all industries as marginal cost declines in response to the elimination of tariffs on intermediate inputs. Conversely, output per U.S. firm increases in all industries by a like amount since $q_u^f = -p_{uu}$. The greatest price decrease (increase in output per firm) occurs in the shortening and cooking oils industry. The markup in this industry is relatively modest at 1.21. The cost share of intermediate farm and food inputs is similarly mod-

[8] For purposes of brevity, the reported results and discussion focus on the food manufacturing sector of the United States. However, results are available for food manufacturing in the ROW from the authors upon request.

[9] Empirical results are generated using a multi-step, nonlinear algorithm to obtain a nonlinear solution to the linearized representation of the model. This approach generates the same results that would be obtained if the nonlinear system of equations were solved directly. For a discussion of these issues, interested readers are referred to: Hertel et al., 1992.

est at 58 percent. However, the cost share weighted input tariff in shortening and cooking oils is 6.45 percent, largest of all the imperfectly competitive industries (see Table 1). As the price change is the product of the fixed markup and the change in costs, price decreases (output per firm increases) by 7 percent.

Other industries which experience significant price decreases (increases in output per firm) include cheese, ice cream, dehydrated food products, frozen specialties, blended flour, confectionary products, cocoa products and flavoring extracts. Price decreases (increases in output per firm) are greater than 3 percent in all of these industries. The common factor in many of these industries is that the cost share weighted input tariff reductions are fairly large. The aggregate cost share of intermediate farm and food inputs in some other industries is fairly small (e.g., cocoa); however, the tariff on the primary intermediate input used in these industries is large (e.g., sugar), leading to the significant reduction in costs. Conversely, price decreases (increases in output per firm) are very minor in industries in which the aggregate cost share of intermediate farm and food inputs is very small or use inputs which are subjected to very low tariffs (e.g., coffee).

Tariff reform in the input markets leads to an increase in the number of domestic firms because lower costs of production generate excess profits for domestic firms, inducing additional domestic entry. Tariff reform in the output market has the opposite effect, however, decreasing the number of domestic firms because of the increased demand for foreign products. The net result depends on which effect—input or output tariff reform—is stronger (Eq. (20)). The changes in the number of U.S. firms in the industries examined are also reported in Table 2. The number of U.S. firms increases in the vast majority of the industries. This implies that the effects of tariff reform in the input market dominate. The largest increase in the number of U.S. firms occurs in the shortening industry because of the large reduction in costs in this industry as discussed above. Large increases in the number of U.S. firms ($\geq 10\%$) also occur in sausage, cheese, ice cream, dehydrated food products, grain milling, flour and rice milling. For many of these industries, the reductions in marginal costs due to input tariff reforms are large while the output tariff reductions are very small. Thus, tariff reform in the output market has little effect on equilibrium in these industries.

The situation in the shortening and ice cream industries, however, is somewhat different. Shortening and ice cream are subject to large output tariffs of roughly 11 percent and 17 percent, respectively. The driving force behind the large increases in the number of U.S. firms in these industries is the assumption of asymmetric preferences. U.S. consumers exhibit an overwhelming preference for domestic shortening and ice cream varieties. [10] This effectively places much greater weight on the reduction in costs for U.S. shortening and ice cream manufacturers than the reduction in output tariffs for ROW manufacturers, leading to the large increase in the number of U.S. firms.

The number of U.S. firms decreases in three industries (canned fruits and vegetables, malted beverages and wine). The reductions in the number of U.S. firms in malted beverages and wine are relatively small and reflect slight displacement of U.S. firms by ROW firms in the final equilibrium. A substantial reduction in the number of U.S. firms occurs in canned fruits and vegetables, however. In this industry, the output tariff is almost five times larger than the cost share weighted input tariff. Also, ROW firms have a significant share of the U.S. market for canned fruits and vegetables. Hence, a greater weight is placed on output tariff reductions, leading output tariff effects to dominate input tariff effects in this industry and decreasing the number of U.S. firms. This is in contrast to the shortening and ice cream industries in which the output tariffs are also significantly larger than the weighted input tariff. In the shortening and ice cream industries, however, consumer preferences for ROW products are very low, and hence, very small weights are placed on the output tariff effects in determination of equilibrium in these industries. As a result, the number of U.S. firms increases in the shortening and ice cream industries.

[10] Because ice cream must be frozen, shipping and handling may be costly as a proportion of total value. Since transport costs are not in the model, the high degree of preference for domestic varieties of ice cream could in fact reflect high transport costs.

Table 3
Percentage changes in markups, prices, output per firm, the number of firms and total output resulting from intermediate input and final output tariff reforms in selected U.S. food manufacturing industries under Cournot conjectures with entry

Industry [a,b]	U.S. firm markups	U.S. firm prices	Output per U.S. firm	Number of U.S. firms	Total U.S. output
CanSpec (6.28)	0.11	−1.73	1.45	11.50	13.13
Cereal (4.53)	0.16	−1.89	1.66	6.98	8.75
RiceMill (10.13)	−0.02	−2.22	2.35	22.53	25.41
WetCorn (6.10)	0.04	−1.27	1.14	14.82	14.58
Cookies (7.82)	0.10	−2.26	2.05	9.94	10.64
Cocoa (5.45)	−0.07	−3.30	3.63	32.25	37.06
Gum (4.00)	0.22	−1.96	1.56	13.48	15.25
MaltBev (4.35)	0.03	−0.32	0.25	2.74	3.00
Extracts (4.91)	0.30	−4.51	4.23	12.43	17.19
Macaroni (5.44)	0.13	−1.97	1.74	6.87	8.74

[a] See Table 1 for the correspondence between industry abbreviations and definitions.
[b] Initial number of U.S. firms in parentheses.

As output per firm increases in all industries and the number of U.S. firms increases in all but three, total U.S. output also increases in all industries with the exception of canned fruits and vegetables, malted beverages and wine. Also, because the increase in the number of U.S. firms greatly exceeds the increase in output per firm in most of these industries, the relative increases in total industry output largely reflect the increases in the number of firms. In the three industries in which U.S. firm numbers decline, total industry output also declines, though by a lesser amount because increases in output per firm offset some of the decreases in the number of firms.

3.2. Cournot Oligopoly

In Table 3, we present the results of joint input and output tariff reforms for selected U.S. food manufacturing industries under the hypothesis of Cournot behavior with entry. [11] The basic criteria used to select these industries are as follows. First, the SCP literature suggests that the critical level of concentration (the four-firm concentration ratio or CR4) for oligopolistic interactions resides between 40 and 60 percent. In this study, 50 percent is arbitrarily chosen as the critical level. In addition, a lower bound on the industry markup of 30 percent (i.e., $MK_u \geq 1.30$) is used to further isolate those industries in which concentration may have led to higher markups. These criteria result in the following industries being chosen for the Cournot experiments: canned specialties, cereal breakfast foods, rice milling, wet corn milling, cookies and crackers, chocolate and cocoa products, chewing gum, malted beverages, flavoring extracts and syrups, and macaroni and spaghetti. [12]

We begin our discussion with an assessment of the procompetitive effects of tariff reform. Changes in markups are insignificant in all industries as the largest change is only 0.30 percent. Furthermore, the direction of change varies among the industries. In rice milling and cocoa, markups decrease slightly, while marginally increasing in the other industries. This is consistent with results obtained by Hertel (1994), who indicates that the direction of change in the markup is analytically ambiguous under Cournot conjectures with entry. More important, however, the changes in markups are insignificant regardless of the direction of change, implying that the procompetitive or anti-competitive effects of tariff reform are negligible. Given the attention accorded to procompetitive effects in recent years, this analysis suggests this concern may have been overstated.

[11] This experiment was also performed under a Cournot no-entry assumption. These results are not presented because of space limitations and because the no-entry scenario is not a sensitivity analysis exercise—it is a different conceptual problem. However, results of the Cournot no-entry experiment are available from the authors upon request.

[12] Though the distilled liquor and coffee industries meet these criteria, the cost share weighted input tariffs and final output tariffs in both industries are negligible. Thus, both industries are excluded from the analysis.

Prices decline in all industries. Because the changes in markups are relatively small, the price decreases are driven primarily by the reductions in marginal costs as a result of input tariff reform. The largest price reduction occurs in extracts as this industry has the largest cost share weighted input tariff of the oligopolistic industries. The changes in output per firm are computed from (Eq. (14)), recognizing that the aggregate perceived demand elasticities are now variable. This gives the following expression for the proportional changes in output per firm: $q_u^f = e_u - p_{uu}$ where e_u is the proportional change in the aggregate perceived demand elasticity (ξ_u). Given that changes in markups are small, changes in e_u must also be small (i.e., $MK_u = (1 - 1/\xi_u)^{-1}$). Thus, the increases in output per firm are due primarily to the reductions in costs (and therefore prices) resulting from input tariff reform.

In order to maintain a zero profits equilibrium, firm entry/exit must occur. The number of U.S. firms increases in all industries. Furthermore, since output per firm and the number of U.S. firms increases in all industries, total industry output must also increase in all industries. These increases in the number of U.S. firms and total industry output are largely due to the effects of input tariff reductions. The largest increases in the number of U.S. firms (and total industry output) occur in those industries which have a relatively large cost share weighted input tariff (e.g., extracts), or alternatively, industries in which the output tariff is negligible (e.g., gum). Thus, we find that input tariff effects also dominate output tariff effects under more collusive forms of imperfectly competitive behavior than implied by monopolistic competition.

Comparing the Cournot and monopolistic competition results, we find that the changes in output per firm are fairly similar for both experiments. However, Cournot behavior generates significantly larger increases in the number of U.S. firms, and therefore total industry output. This is largely because of the proportional change formulation of the model, such that $n_u = dN_u/N_u$. The initial number of firms is signficantly smaller in the Cournot case. Thus, even if dN_u is the same in both the monopolistic competition and Cournot experiments, n_u would be much larger for the Cournot scenario.

The results obtained under the Cournot behavioral assumption largely substantiate qualitative predictions obtained by Hertel (1994) under similar assumptions (i.e., Cournot conjectures with entry). However, Hertel considered only tariff shocks in the final output market, such that all changes in his model were driven by changes in the competitiveness of foreign firms. The introduction of tariff reforms in input markets, however, increases the competitiveness of domestic firms, thereby dampening changes in response to output tariff reform. In particular, input tariff reform increases the likelihood that the number of domestic firms and total industry output will increase.

4. Summary and conclusions

The primary objective of this research was to assess the effects of trade reform on imperfectly competitive U.S. food manufacturing industries. Manufactured foods account for over half of the total value of world trade in farm and food products. Also, traded intermediate farm and food products account for a significant proportion of the variable costs of production in food manufacturing. Hence, trade reform may have very significant effects on equilibrium in the food manufacturing sector. Yet, these effects have received scant attention in the trade literature. A two country (U.S. and ROW) model of monopolistically competitive, disaggregate food manufacturing industries was developed to assess the effects of joint tariff reforms in the intermediate input and final output markets. A key empirical finding is that the effects of input tariff reform generally outweigh the effects of output tariff reform in the U.S. food manufacturing sector. Input tariff reform reduces the costs of production for U.S. food manufacturers and thereby increases their competitiveness in the world market. Output tariff reform, on the other hand, serves to increase the competitiveness of foreign manufacturers. Therefore, the net effect is ambiguous due to the conflicting effects of the two tariff reforms. Hence, the need for empirical analysis.

The results presented in this paper show that input tariff reform dominates the effects of output tariff cuts, so that simultaneous liberalization leads to an increase in the number of U.S. firms and total output in most of the domestic food manufacturing industries. Indeed, this outcome can arise even in the presence of significant escalation of tariffs between the intermediate input and final output markets. The result depends on the initial values of certain parameters, such as per firm market shares and the relative sizes of the economies.

The highly concentrated nature of some of the food manufacturing industries is suggestive of oligopolistic behavior. In order to determine whether our results were robust to changes in the degree of interfirm rivalry, the tariff reform experiment was repeated for selected industries engaging in Cournot competition in the presence of entry. Since the changes in markups were negligible, our results suggest that the importance of the procompetitive or anti-competitive effects of tariff reform has been overstated in the case of the U.S. food industry. More important, the effects of intermediate input tariff reform dominated the effects of output tariff reform in the Cournot experiments, as was the case under monopolistic competition. This suggests that this finding is not sensitive to changes in the degree of interfirm rivalry in the marketplace.

Our central finding is that the existing U.S. tariff profile discriminates against domestic food manufacturers. Tariffs in the output market offer protection to U.S. food manufacturers. However, this protection is significantly outweighed by tariffs on purchased inputs, with the result that domestic food manufacturers are less competitive relative to their foreign rivals. This may also help to explain the decrease in the U.S. share of world processed foods trade. Also, the number of food varieties available to consumers is lower, as is total domestic output of food products. In a broader sense, this analysis also suggests that the overwhelming concern with output tariffs may be somewhat misplaced. Input tariff shocks can play a very important role in determining the outcome of trade reform. Indeed, they can prove to be the dominant force in trade policy reform.

Acknowledgements

Funding provided by the NC-194 Regional Research Project for data collection and preliminary analysis is gratefully acknowledged.

References

Anderson, S., De Palma, A. and Thisse, J., 1989. Demand for differentiated products, discrete choice models and the characteristics approach. Rev. Econ. Stud., 56: 21–35.

Brander, J. and Spencer, B., 1984. Trade warfare: tariffs and cartels. J. Int. Econ., 16: 227–242.

Brown, D., 1991. Tariffs and capacity utilization by monopolistically competitive firms. J. Int. Econ., 30: 371–381.

Connor, J., Rogers, R., Marion, B. and Mueller, W., 1985. The Food Manufacturing Industries: Structure, Strategies, Performance and Policies. Lexington Books, Lexington, MA.

Devarajan, S. and Rodrik, D., 1991. Procompetitive effects of trade reform: results from a CGE model of Cameroon. Eur. Econ. Rev., 35: 1157–1184.

Hertel, T., 1994. The procompetitive effects of tariff reform in a small, open economy. J. Int. Econ., 36: 391–411.

Hertel, T., Horridge, M. and Pearson, K., 1992. Mending the family tree: a reconciliation of the linearization and levels schools of applied general equilibrium modeling. Econ. Mod., 9: 385–407.

Lanclos, K. and Hertel, T., 1995. Endogenous product differentiation and trade policy: implications for the U.S. food industry. Am. J. of Agr. Econ., 77: 591–601.

MacDonald, S. and Lee, J., 1992. Assessing the international competitiveness of the United States food sector. Paper presented at the Annapolis meeting of the International Trade Research Consortium.

Markusen, J., 1981. Trade and gains from trade with imperfect competition. J. Int. Econ., 11: 531–551.

NC-194 Research Project Proposal, 1988. The Organization and Performance of World Food Systems: Implications for U.S. Policies.

Padberg, D. and Westgren, R., 1979. Product competition and consumer behavior in the food industries. Am. J. Agr. Econ., 61: 620–625.

Salop, S., 1979. Monopolistic competition with outside goods. Bell J. of Econ., 10: 141–156.

Schmalensee, R., 1978. Entry deterrence in the ready-to-eat breakfast cereal industry. Bell J. Econ., 9: 206–227.

Sutton, J., 1991. Sunk costs and market structure. MIT Press, Cambridge.

Venables, A., 1987. Trade and trade policy with differentiated products: a Chamberlinian-Ricardian model. Econ. J., 97: 700–717.

Vousden, N., 1990. The Economics of Trade Protection. Cambridge University Press, Cambridge.

Yates, P., 1959. Forty Years on Foreign Trade. London.

Yeats, A., 1988. The escalation of trade barriers. In: J. Finger and A. Olechowski (Editors), The Uruguay Round: A Handbook for the Multilateral Trade Negotiations. World, Bank, Washington, DC.