THE IMPLICATIONS OF THE WTO NEGOTIATIONS ON THE CANADIAN CHICKEN MARKET: TWO REPRESENTATIONS OF CHICKEN AND STOCHASTIC WORLD PRICES

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Abstract

Current Doha Development Agenda (DDA) World Trade Organisation negotiations include proposals that would affect the trade barriers that protect Canada's chicken producers from foreign competition. This research analyses the effects of the most recent proposals to emerge from the DDA negotiation on Canada's chicken industry. We develop a partial-equilibrium model that generates welfare effects for the Canadian chicken industry supply chain. We also introduce stochastic prices to evaluate the effects of world price instability on the Canadian chicken industry. The model is also adapted to represent chicken as two distinct products; white meat and dark meat. Simulation results suggest that the welfare effects of the DDA proposals on the Canadian chicken industry would be small, providing that chicken receives the sensitive products designation. Liberalisation leads to higher total welfare in the chicken industry, which is accounted for by consumer welfare that increases by a larger amount than producer welfare decreases. These results hold across models that incorporate risk and that differentiate products.

1.0 INTRODUCTION

Canada's chicken industry has operated under a system of supply management since 1979. The supply-managed system is based on three pillars: production controls, a cost-of-production pricing formula and protection from relatively low-priced foreign products. The combination of these pillars has led to relatively high chicken prices in Canada and resultantly high returns to chicken producers.

Current World Trade Organisation (WTO) negotiations have included discussions on liberalising trade in agricultural products through, among other methods, lowering tariff barriers between member countries. Canada's chicken industry is currently protected by a tariff rate quota (TRQ), and could be affected by new rules on tariff barriers. The TRQ that currently insulates the Canadian chicken industry from foreign competition is comprised of a low tariff on a small volume of imports and a prohibitively high tariff on imports above the defined minimum access level. The most recent proposals to emerge from the Doha Development Agenda (DDA) negotiations indicate that TRQs that insulate Canada's supply managed industries would be disciplined in two ways: first through an increase in the volume of imports allowable under the low tariff rate, and second through a reduction in the higher, over-quota, tariff rate. Such disciplines could expose the Canadian chicken industry to more competition from foreign suppliers.

We develop a partial equilibrium simulation model of the Canadian chicken industry in order to estimate the welfare effects of proposed WTO disciplines. Up to date production, consumption and price data are used in combination with elasticities from other studies to develop a model that accommodates a range of trade policy scenarios and modelling strategies. Welfare estimates are calculated along the chicken supply chain including producers, processors and consumers. The model is simulated under two different aggregation strategies: chicken as a single homogenous product, and a less restrictive version that treats chicken as two distinct products that are differentiated by cut. We also introduce a stochastic element to international prices to simulate the effects of increased price risk on the Canadian chicken industry.

The simulation results incorporate the most recent proposals to emerge from the DDA negotiations, and assume that chicken will receive the *sensitive products* designation. This assumption is key to the results because such products would not be subjected to the same levels of tariff cuts as other agricultural products if a DDA deal is done. We find that the current DDA proposals would have relatively small welfare effects on the Canadian chicken industry. Proposed cuts to over quota tariff rates would leave chicken tariffs prohibitively high, and the only effect on chicken imports would come through an increase in the minimum access commitment. The net effect is an increase in total welfare, which is accounted for by an increase in consumer welfare that is larger than the decrease in producer welfare. These results hold across modelling strategies, however the magnitudes of welfare effects are larger in the less restrictive two-good model.

2.0 OVERVIEW OF THE CANADIAN CHICKEN INDUSTRY

The Canadian chicken industry has operated under a supply management system since 1979. Supply management is based on three pillars; import limits, production controls, and price determination. The supply of chicken is regulated using a production quota system, so that regulated chicken producers must hold production quota in order to produce and ship their product to the market. Producers pay fees for the right to produce, which implies that the production quota is a valuable asset. Producer prices are determined at the provincial level using a live-price cost of production formula that includes input costs (the price of chicks and feed) plus a producer margin. To maintain the stability of supply in Canada, the supply management system limits imported products. Chicken imports are divided into products that are on the Import Control List (ICL) (live chickens, eviscerated fresh and chilled or frozen chicken, processed and smoked chicken products) and products not on this list (TV dinners, soup, etc.). Chicken products that are on the ICL are subject to tariff-rate quotas (TRQs), while non-ICL products are not (AAFC, 2006).

There are three components to a TRQ: a low duty rate (in-quota tariff), a minimum import access level for entry at that low tariff rate, and a higher tariff rate (over-quota tariff) for over-access imports. The in-quota tariff for chicken under the North American Free Trade Agreement (NAFTA) is zero percent, and under the WTO agreement is 5% (Canada Border Service Agency, 2009). The over-quota tariff rate for chicken is 238%. Under NAFTA, the annual import access for chicken is 7.5% of the previous year's domestic production, and under the WTO Agreement on Agriculture is 5% of domestic consumption. The minimum market access level is set to the higher limit between the levels negotiated under NAFTA and the WTO (*i.e.* 7.5% of the previous year's domestic production).

The cost-of-production formula, production quotas, and import restrictions have driven Canadian chicken prices considerably higher than world prices, putting Canadian chicken processors who are willing to export at a disadvantage in the world market. However, since the Canadian chicken market is predominantly a white meat market (AAFC, 2006). Canadian processors have an opportunity to sell dark meat surplus on the international market. In order to compete, Canadian processors lower their export prices to the international level. Therefore, the value of Canadian chicken exports is much lower than the value of Canadian chicken imports, although the volumes are similar. The average value of an import-unit of chicken (68.3% of which is white) is C$2.61/kg while the average value of an export-unit (84.4% of which is dark) is C$1.87/kg (AAFC, 2008). The significant price difference between the products speaks to the heterogeneity of white and dark chicken meat.

3.0 MODEL SPECIFICATION

3.1 Chicken Representation

Trade policy analyses of chicken markets have traditionally treated chicken as a single homogeneous product, regardless of production location or cut (Rude and Gervais, 2006; Peterson and Orden, 2004). However, Huff *et al.* (2000) found that the pattern of Canadian

chicken consumption and trade suggested that chicken meat had become two differentiated products. Hence, they proposed differentiation by cut as an area for further research.

A competitive partial equilibrium model with disaggregated high value (white meat) and low value (dark meat) cuts of chicken, and a country-of-origin differentiation has been studied in the context of sanitary measures (Peterson and Orden, 2004). Thompson *et al.* (2008) conducted research to analyze how three models that are based on three different representations of chicken (chicken as a single homogeneous good, as two homogeneous co-products, and as heterogeneous goods based on country of origin) respond to different external shocks and different trade policy scenarios. Thompson *et al.* (2008) found that responses in chicken production, consumption, and prices are similar across models when the shocks are not directly related to the chicken market (feed price shock, changes in income, or changes in substitute's prices). The similarity across models disappears when considering changes that are specific to chicken markets.

Given the patterns of Canadian chicken consumption and trade, we develop two simulation models in this research. One treats chicken as a single homogeneous product and the second represents chicken as two differentiated products (white meat and dark meat). The comparison of results from the more (single good) and the less (two-good) restrictive model provides insights into the methodological question of the importance of disaggregating chicken by cut.

3.2 Price Risk

One of the core objectives of Canada's supply managed system of pricing and production is price and income stability (Rude and Gervais, 2006). The cost of production pricing formula adjusts to changing input prices, thereby stabilising producer incomes. A new WTO agreement that would expose Canadian chicken producers to more international competition may subject Canadian producers to variable flows of imports and lead to more volatile prices and income.

We introduce price risk into the model by allowing world prices to follow a stochastic process. Following Rude and Gervais (2006), a time-series of US chicken prices is used to find the best fitting probability distribution for the world price using the distribution fitting software BESTFIT. The time series data set is an 18-year series of monthly US prices (12-city composite wholesale price of chicken) plus a transportation cost (C$ 0.1/kg, CFC, 2009), converted to Canadian dollars. The best fitting distribution for the time series is a normal distribution with a mean of 1.75 and standard deviation of 0.25. The same procedure is followed to determine the appropriate probability distribution for the world price of white and dark meats when chicken is treated as two distinct products. In this case, time series data sets of monthly wholesale prices of breast (for white meat) and legs (for dark meat) are used. The best fitting distribution for the world indicator price of white chicken meat is a normal distribution with a mean of 2.63 and standard deviation of 0.42. The world indicator price of dark chicken meat has a normal distribution with a 1.35 mean and a 0.22 standard deviation.

4.0 DATA AND SIMULATION MODEL

4.1 Parameters and Data

We impose the small country assumption on Canada in the simulation model. Canadian exports account for just 2% of world chicken exports, compared to 38% for the US and 39% for Brazil (USDA, 2009). In order to build the one-good model, the elasticities of demand and supply, and the farm-level marginal cost are required. The elasticity of demand is taken from an AAFC (2007) study. Moschini and Meilke (1991) note that published demand elasticities are typically estimated at the retail level, and therefore an assumption about the marketing margins is needed to analyse different stages of the supply chain (*e.g.* wholesale level). We assume a constant processing margin across output levels (Moschini and Meilke, 1991). An elasticity of supply of 0.8 is assumed based on an estimate of US long-run broiler supply from Chavas (1978). Canadian chicken supply may be more elastic that US supply because of unused capacity at the farm level (Moschini and Meilke, 1991), so we conduct sensitivity analysis on this parameter in the simulations. Additional parameters are required to build the model that differentiates chicken by type of cut, such as the own-price and cross-price elasticities of demand. Previously estimated own-price and cross-price elasticities calculated at the retail level are used. Table 1 lists the parameters used in the two models.

Table 1: Parameters

Canada	Chicken	White chicken	Dark chicken
Price elasticity of supply	0.8 [a]	0.8 [a]	0.8 [a]
Price elasticity of demand	-0.7 [b]		
Own-price elasticity of demand		-1.47 [c]	-0.93 [c]
Cross-price elasticity of demand		0.07 [c]	0.49 [c]

Sources: [a] Chavas (1978) [b] AAFC (2007), [c] and Goddard *et al.* (2007).

The data used to calibrate the model for the representation of chicken as a single homogeneous product correspond to national supply-disposition (USDA, 2009), based on an average from 2004-2007. The two-good model requires separate production, consumption, and trade data for purposes of calibration. These data are not available in this form, so a mechanical process is used to generate data for the two-good model. Chicken production, consumption, and trade data are separated into white meat (chicken breasts) and dark meat (chicken legs). Chicken production is disaggregated based on an assumed chicken cut-out rate of 53.3% to 46.7% between white and dark meat (CFC, 2009). Following Thompson *et al.* (2008), the shares of white and dark meat as components of total chicken trade are estimated with traded prices of white and dark meats and the average price of all chicken trade. The shares of imports and exports of each type of meat are calculated with the following formula:

$$ATP = Sh_{white} * P_{world}^{white} + \left[1 - Sh_{white}\right] * P_{world}^{dark} \qquad \textbf{(1)}$$

where *ATP* is the average traded price, Sh_{white} is the share of imports/exports of white meat, P_{world}^{white} represents the world indicator price of white meat, and P_{world}^{dark} is the world indicator price of dark meat. The world price indicators are the average US wholesale price of breast for white meat and the average US wholesale price of legs for dark meat, plus a transportation cost of C$0.1/kg (CFC, 2009). The share of dark meat as a component of total trade is equal to $1 - Sh_{white}$. Consumption of each type of meat is calculated as the residual of the market clearing balance.

4.2 Simulation Model

4.2.1 Demand: One-good Model

The model is built around a linear wholesale domestic demand function for chicken and a linear farm-level domestic supply function that is subject to production controls. The inverse demand function is represented by:

$$P = \frac{1}{\delta} D - \frac{\gamma}{\delta} \qquad \textbf{(2)}$$

where P is the domestic price, D is domestic demand, $\delta = \frac{\eta Qd}{P_{wholesale}}$, $\gamma = Qd\,(1-\eta)$, $P_{wholesale}$ is the observed wholesale price[1], Qd is the observed quantity demanded, and η is the elasticity of demand.

4.2.2 Demand: Two-good Model

We expand the one-good model to represent the demand for white meat and dark meat in the two-good model. Since white and dark chicken meat can be considered substitutes[2], the demand functions for each type of meat are:

$$P_w = \frac{1}{\delta_w} D_{white} - \frac{\gamma_w}{\delta_w} + \frac{\psi_w}{\delta_w} P_d \qquad \textbf{(3)}$$

$$P_d = \frac{1}{\delta_d} D_{dark} - \frac{\gamma_d}{\delta_d} - \frac{\psi_d}{\delta_d} P_w \qquad \textbf{(4)}$$

where D_{white} is the domestic demand for white chicken meat, Pw is the domestic price of white meat, $\gamma_w = Qd_{white}\,(1-\eta_w)$, $\delta_w = \frac{\eta_w Qd_{white}}{P_{white}}$, $\psi_w = \frac{\eta_{wd} Qd_{white}}{P_{dark}}$, Qd_{white} is the observed quantity demanded of white meat, η_w is the own-price elasticity of demand, P_{white} is the observed

wholesale price of white meat[3], and η_{wd} is the cross-price elasticity of demand for white meat with respect to the price of dark meat. Dark meat variables are defined using the same convention ($\gamma_d = Qd_{dark}(1-\eta_d)$, $\delta_d = \frac{\eta_d Qd_{dark}}{P_{dark}}$, $\psi_d = \frac{\eta_{dw} Qd_{dark}}{P_{white}}$).

4.2.3 Supply

Constructing simulation models for supply-managed industries is complicated by the lack of observable price and quantity combinations from which a supply function can be derived - output and price combinations are not determined by the intersection of demand and supply. However, it is possible to construct a supply function if the departure from marginal-cost pricing (that would exist in a competitive industry) can be determined from the values of production quotas (Moschini and Meilke, 1991). A supply function can be fitted through the observed output and the implied marginal cost, and can be represented as:

$$P = \frac{1}{\beta} S - \frac{\alpha}{\beta} \qquad \textbf{(5)}$$

where S is the domestic supply, P is the domestic price, $\alpha = Qs(1-\varepsilon)$, $\beta = \frac{\varepsilon Qs}{Mc}$, Qs is the observed quantity supplied, M_c is the implied marginal cost, and ε is the elasticity of supply. The implied marginal cost, M_c, is not observable, and is estimated using production quota values. The following formula is used to derive the implied marginal cost:

$$M_c = P_{farm} - Qr \qquad \textbf{(6)}$$

where M_c is the marginal cost at the competitive level, P_{farm} is the price paid to producers at the farm gate reported by CFC, and Qr is the rental value of production quota. Because production quota is a valuable asset, the rental value of production quota can be estimated using the capitalization formula[4]. The capitalization formula is defined as:

$$\lambda = \frac{Qr}{Qv} \qquad \textbf{(7)}$$

where λ is the discount rate, Qr is the rental value of production quota (measured in kg of eviscerated meat), and Qv is the asset value or capital value of production quota (C$/12 kg of live weight). The rental value of production quota can be estimated with the observed capital values of production quotas and an assumed discount rate[5]. Table 4.3 presents the marginal cost values[6] computed with discount rates of 7%, 10%, and 13% from 2004 to 2007.

Table 2: Marginal cost

Year	Capital value of quota (C$)	Rental value of quota (C$) 7%	10%	13%	Farm Price (C$)	Marginal cost (C$) 7%	10%	13%
2004	52.57	0.42	0.59	0.77	1.66	1.24	1.06	0.88
2005	53.97	0.43	0.61	0.79	1.62	1.19	1.01	0.83
2006	56.51	0.45	0.64	0.83	1.55	1.10	0.91	0.72
2007	57.63	0.46	0.65	0.85	1.73	1.28	1.08	0.89
Average	55.17	0.44	0.62	0.81	1.64	1.20	1.02	0.83

Sources: Capital Value of one unit of production quota (C$/12 kg live weight) from CFO (2007).
Rental value of production quota is equal to the capital value of quota (C$/kg) multiplied by the producers' discount rate. Marginal cost price is equal to farm price less the rental value of production quota.

4.2.4 Supply When Producers are Risk Averse

Unstable world chicken prices could expose the Canadian chicken market to volatile imports if over-quota tariffs drop significantly. Because price and income stability are two of the key objectives of supply managed policies, it is important to consider how producers would respond to higher levels of risk after the implementation of a liberalising trade agreement. We assume that producers are risk averse (Gunjal and Legault, 1995), and modify the supply function from equation (5) with a risk premium[7]. The risk-augmented inverse supply function is

$$P = \frac{1}{\theta} S - \frac{\varphi}{\theta} + \rho \qquad \textbf{(8)}$$

where $\varphi = Qs(1-\varepsilon)$, $\theta = \frac{\varepsilon Qs}{M_c}$, S is the farm supply, P is the expected marginal cost, and ρ is the risk premium. The risk premium is calculated as:

$$\rho = \text{CARA} * \sigma^2 * S \qquad \textbf{(9)}$$

where CARA is the coefficient of absolute risk aversion, σ^2 is the variance of producer's price, and S is farm supply. The variance of the producer's price is taken from the normal probability distribution of the world price (Rude and Gervais, 2006). The CARA coefficient is calculated as:

$$\text{CARA} = \frac{\text{CRRA}}{\pi} \qquad \textbf{(10)}$$

where CRRA is the coefficient of relative risk aversion and π is the baseline level of producer surplus. We use a CRRA of 4, taken from the OECD (2004).

The baseline scenarios for the one- and two-good models are used to calculate welfare measures in the Canadian chicken market under the current TRQ regime. These baselines serve as starting points from which to calculate the distribution of welfare following trade liberalisation, and

when international prices are modelled stochastically. The analysis is done at the wholesale level, and marketing margin assumptions are implemented to generate measures of downstream consumer surplus.

4.3 Latest WTO Draft Modalities

The latest draft modalities to emerge from DDA negotiations (WTO, 2008) propose cuts to tariff rates on agricultural products according to a tiered formula in which higher tariffs (out-of-quota tariffs) would have to be cut more than relatively lower tariffs. Developed and developing country members would have different thresholds and tariff reductions. For developed countries, tariffs below 20% are to be cut by 50% and tariffs above 75% are to cut by 70%. All lower bound tariffs (in-quota tariffs) would be reduced either by 50% or to 10%, whichever results in a lower tariff. Where the in-quota tariff rate is already bound at or below 5%, it should be reduced to zero at the end of the first year of the implementation period (WTO, 2008).

4.3.1 Sensitive Products

The latest draft modalities (WTO, 2008) include proposals that would allow member countries to categorise products as *sensitive* for domestic political reasons. Developed countries would be able to designate 4-6% of their products as sensitive, or 6-8% of products if more than 30% of their products are in the top band of the tariff formula (WTO, 2008). Tariffs on products that are designated as sensitive may be cut by one-third, one-half or two-thirds of the reduction that would otherwise be required by the tiered reduction formula. To compensate for these smaller tariff cuts, member countries must expand the level of import quotas at the lower tariff rate (in-quota tariff). For developed countries, if the minimum deviation from the tiered reduction formula (one-third) is selected, then the minimum import quota expansion should be 3-5% of domestic consumption. If the maximum deviation from the tiered reduction formula (two-thirds) is selected, then the minimum import quota expansion should be 4-6% of domestic consumption (WTO, 2008). Although these numbers are still under negotiation, they represent the best estimates of the possible consensus, should the current framework be accepted as a modalities package.

Canada's supply managed industries enjoy very strong political support (House of Commons, 2009), and it is likely that chicken would be considered sensitive in the implementation of a DDA agreement. We incorporate trade liberalisation scenarios into the model under the assumption that chicken will be categorised as sensitive, and will therefore be subject to relatively modest tariff rate reductions.

4.4 TRQ Liberalization with Supply Management

According to the latest draft modalities (WTO, 2008), the Canadian in-quota tariff for chicken products would be reduced to zero percent. The elimination of the in-quota tariff may or may not change market access, depending on whether the import quota is binding. That is, if the import

quota is already filled, then a lower tariff rate would not increase the flow of chicken imports into Canada. The import quota rate fill for Canadian chicken industry is currently above 100% (CFC, 2007), which means that the import quota is binding and the elimination of the in-quota tariff would not affect import volumes. However, if the world price is below the domestic price then the elimination of the in-quota tariff would reduce domestic prices as cheaper imports enter the Canadian market. The in-quota tariff for chicken under NAFTA is zero percent, and because the US is the largest foreign supplier of chicken products to Canada (approximately 85% of total chicken imports in 2008 (USDA, 2009)), the elimination of the in-quota tariff may not have a significant effect on domestic prices or producer's revenue.

The current over-quota tariff for Canadian chicken products is 238%, and the proposed DDA tariff cut for this category is 70%. However Canada's supply managed industries are likely to receive sensitive product designation, and WTO members may deviate from the tiered reduction formula in such cases. The current DDA proposals allow member countries to deviate from the 70% cut by one-third, one-half or two-thirds. We assume that the maximum deviation is applied to Canadian chicken imports, which means that the over-quota tariff would be reduced from 238% to 182.5%, and the import quota level would be set at 10% of domestic consumption[8].

It is necessary to calculate how much the over-quota tariff can be reduced without allowing out-of-quota imports into Canada in order to determine if the over-quota tariff reduction would have an effect on the Canadian chicken market. If the cut to the over-quota tariff rate does not reduce the rate below prohibitive levels, then market access would not increase above the quota level. We calculate the water in the tariff (WIT) by measuring the difference between the over-quota tariff rate and the nominal rate of protection (NRP) (Martin and Wang, 2004; Barichello and Zhang, 2008). The NRP can be expressed as:

$$NRP = \frac{(Pc - P_{world}^{cif})}{P_{world}^{fob}} * 100 \qquad \textbf{(11)}$$

where Pc is the Canadian wholesale price of chicken, P_{world}^{cif} is the landed-price of chicken including insurance and freight, and P_{world}^{fob} is the world free-on-board price of chicken. The WIT is defined as:

$$WIT = T - NRP \qquad \textbf{(12)}$$

where T is the applied over-quota tariff rate.

If the wholesale price (Pc) used to calculate the NRP is not at the competitive level, then the WIT may not be an accurate representation of how much the over-quota tariff can be reduced without affecting the Canadian chicken market (Barichello and Zhang, 2008). If the over-quota tariff if reduced beyond the WIT but less than the potential WIT, then imports over the minimum access level could still be restricted if the CFC increases output and the domestic wholesale price falls towards competitive levels. We estimate a counterfactual competitive wholesale price for the Canadian chicken market to account for this consideration. The wholesale price (Pc) under a supply-managed industry can be expressed as:

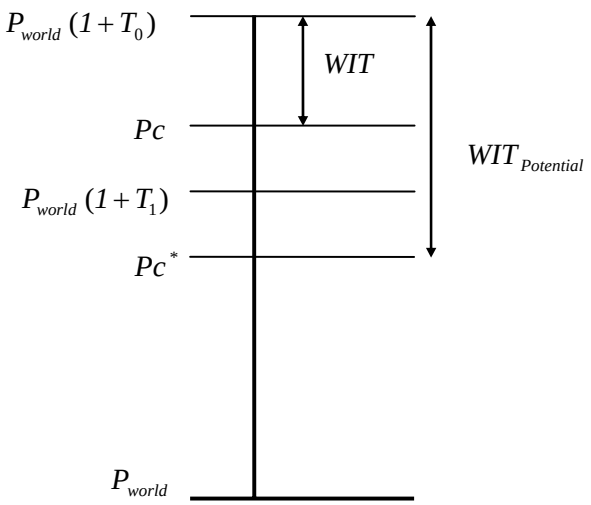
$$Pc = P_{farm} + P_{margin} \quad \textbf{(13)}$$

where P_{farm} is the producers' price of chicken at the farm-level (under the supply-managed industry), and P_{margin} is the processing margin, which is assumed to be constant. The farm price (equation 6) is equal to the marginal cost price (producers' price at the competitive level) plus the rental value of production quota (Qr). Then, the wholesale price in a perfectly competitive market can be represented as:

$$Pc^{*} = Mc + P_{margin} \quad \textbf{(14)}$$

where Pc^{*} is the counterfactual Canadian wholesale price at the competitive level, Mc is the marginal cost, and P_{margin} is the processing margin. Figure 4 shows a situation in which the over-quota tariff is reduced from T_0 to T_1, and $T_0 - T_1 > WIT$. In this case, chicken imports would enter the Canadian market because the landed-price (world price plus the applicable over-quota tariff) is less than the domestic price ($P_{world}(1+T_1) < Pc$). However, if the WIT is calculated with the Canadian wholesale price described by equation (14), then the landed price would be greater than the domestic price ($P_{world}(1+T_1) > Pc^{*}$), and no imports would enter the Canadian market.

Figure 1: Water in Tariff



Source: Barichello and Zhang (2008)

The potential NRP (the NRP calculated at Pc^{*} instead of Pc) is defined as:

$$NRP_{Potential} = \frac{(Pc^{*} - P_{world}^{cif})}{P_{world}^{fob}} 100 \quad \textbf{(15)}$$

where Pc^* is the domestic wholesale price at the competitive level, P_{world}^{cif} is the landed price without a tariff, and P_{world}^{fob} is the free-on-board world price as (Barichello and Zhang, 2008). The corresponding potential WIT is defined as:

$$WIT_{Potential} = T - NRP_{Potential} \qquad \textbf{(16)}$$

where T is the applied over-quota tariff rate and $NRP_{potential}$ is the potential NRP calculated by equation (15). This potential WIT provides a more accurate estimate of how much the over-quota tariff can be reduced while still restricting over-quota access of imported chicken into Canada. We model both the WIT and the $WIT_{potential}$ in our simulations for comparison.

5.0 WELFARE AND SENSITIVITY ANALYSIS

We generate two baseline models; one with, and one without, price risk. Two versions of each baseline model are presented: one in which chicken is assumed to be a single homogenous product, and a second less restrictive version in which chicken is modelled as two distinct products.

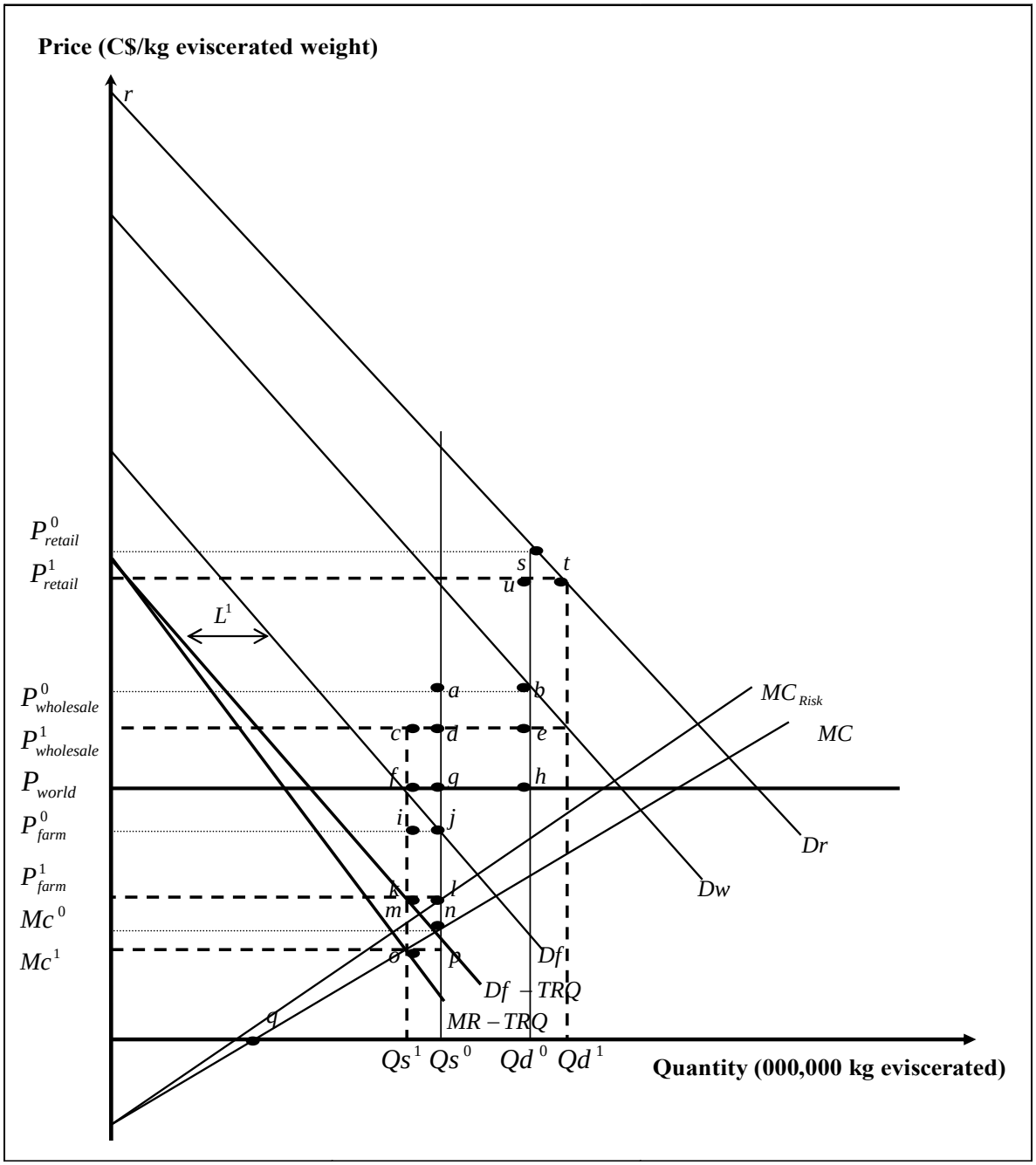
5.1 One-good Model

Figure 2 illustrates the three stages of the chicken supply chain that are modelling in this research. Production controls are applied at the farm level, international trade occurs at the wholesale/processing level and final consumption is modelled at the retail level. The retail-level demand function (Dr) represents demand for chicken products by consumers and P_{retail} is the retail price. The demand facing processors is represented by the wholesale-level demand function (Dw), which is obtained by subtracting the marginal cost of marketing services from the retail demand function (Dr). The wholesale price ($P_{wholesale}$) is paid to processors from retailers. The farm-level demand function (Df) represents demand facing producers, which is obtained by subtracting the marginal cost of processing services from the wholesale demand function (Dw). The marginal cost function (MC) represents the supply of chicken at the farm-level. The farm price (P_{farm}) is the price paid to producers at the farm gate and marginal cost (M_c) is found using the rental value of production quota.

In order to simulate a range of trade scenarios in a supply-managed industry, we must make a behavioural assumption on the part of the supply management authority, i.e., the CFC. If the marketing board acts as a pure monopolist, then output is set where marginal revenue equals marginal cost. However, given that the demand for chicken is inelastic, the marginal revenue received by the monopolist at this point would be negative (Rude and Gervais, 2006)[9]. Also, the monopoly solution (as inferred from setting output where marginal cost equals marginal revenue) results in a smaller level of output than currently observed production quota. This suggests that the production quota is not set at the profit-maximizing level. Following Rude and Gervais (2006), we assume that the marketing board behaves as a constrained monopolist in which the

marketing board's quota decision is inhibited by the price elasticity of demand for chicken. We incorporate this into the model by calibrating an adjusted marginal revenue function to intersect the marginal cost (MC) curve at the initial level of production (Qs^0). We introduce the TRQ to the model by applying an import quota (L) at the wholesale level. Domestic quantity demanded (Qd) is the sum of the production quota (Qs) and the volume of imports (L). Imports enter the Canadian market at the world price (P_{world}).

Figure 2: Import quota expansion: one-good model



Producer surplus is measured as the difference between producer revenue (price at the farm level multiplied by domestic supply), and the area under the marginal cost curve between the intercept and the level of domestic supply. Processor revenue is calculated as the difference between the wholesale price and the farm price of chicken multiplied by the level of domestic supply. Consumer surplus is an aggregated value that includes the processor, retailer, and consumer surplus. It is calculated as the difference between the retail price and the wholesale price, multiplied by the level of domestic consumption, plus the area under the retail demand function up to the retail price.

Import quota rents are calculated as the difference between the wholesale price and the world price multiplied by the volume of imports. The import quota level for 2007 was calculated as 73 million kg; however, the volume of imports that year was 152 million kg (CFC 2007). The volume of Canadian chicken imports is above the minimum market access due to supplementary imports under the "import-to-re-export" program, which allows imports of chicken and chicken products into Canada to be further processed with the restriction that all imports under this program be exported within a six-month period.

Import data include imports under the "import to re-export" program and imports that are not subject to TRQs (*e.g.* imports of non-ICL products). Seventy-four million kg of chicken were imported under the "import to re-export" program in 2007 (CFC, 2007). According to the latest draft modalities (WTO, 2008), imports to re-export (including where the obligation to re-export is in a processed form) should not be counted as imports in our model under the minimum market access commitment. Therefore, the initial level of imports is calculated as 7.5% of production (the value of the current minimum access level) in order to compare the increased market access from 7.5% of domestic production to 10% of domestic consumption under the DDA proposals. Total industry welfare is calculated as the sum of producer surplus, consumer surplus, processor revenue, and import quota rents.

Figure 2 illustrates the effects of import quota expansion on the Canadian chicken market. The production quota is set by assuming that the marketing board acts as a constrained monopolist, and faces $Df - TRQ$ as its effective demand. The producers' residual demand function ($Df - TRQ$) and its corresponding marginal revenue function ($MR - TRQ$) shift downward due to the increase in market access. As a result, the level of domestic supply goes down from Qs^0 to Qs^1, farm price declines from P^0_{farm} to P^1_{farm}, and marginal cost decreases from Mc^0 to Mc^1. Since more low-priced foreign chicken enters the Canadian market, the domestic wholesale price decreases from $P^0_{wholesale}$ to $P^1_{wholesale}$ and domestic consumption increases from Qd^0 to Qd^1.

The change in producer surplus consists of two areas: the rectangle $P^0_{farm}\ jl\ P^1_{farm}$, which is the loss associated with lower farm price, and the trapezoid *lkon* representing the loss due to lower domestic supply. The change in import quota rents consist of three areas: the rectangle *abed* that is lost due to a lower wholesale price, the area $[P^1_{wholesale} - P_{world}]*[Qd^1 - Qd^0]$, representing the gain due to higher domestic demand, and the area *cdfg*, which is the gain attributed to lower domestic supply.

The change in processor revenue consists of three areas: the area $P^0_{wholesale}\ adP^1_{wholesale}$ represents the loss associated with a lower wholesale price, the area $cdlk$ that is the loss owing to lower domestic supply, and the rectangle $P^0_{farm}\ ikP^1_{farm}$ indicating the gain generated by lower farm price.

The change in consumer surplus consists of three areas: the triangle stu, which is the gain due to a lower retail price, the area $[P^1_{retail} - P^1_{wholesale}]*[Qd^1 - Qd^0]$ representing the gain associated with higher domestic demand, and the area $P^0_{wholesale}\ beP^1_{wholesale}$ that is attributable to a lower wholesale price.

The welfare analysis when world prices are stochastic considers a marginal cost curve that is adjusted for a risk premium (MC_{Risk}), as described by equation (8), and assumes that chicken producers are risk averse. The introduction of the risk premium increases the slope of the marginal cost function. Import quota rents, processor revenue, and consumer surplus measures are calculated as described above. The change in producer surplus includes the losses associated with lower farm price and lower domestic supply and the loss associated with the risk premium that induced the shift in the marginal cost function.

5.2 Two-good Model

The pattern of consumption and trade of chicken in Canada suggests that consumers do not view chicken as a single homogeneous good. We therefore relax the assumption that chicken is a single homogenous product and simulate the model for two distinct products. All surplus calculations are performed in the same manner as described for the one-good model, however demand and supply functions are derived for each product (dark and white meat) individually and surplus measures are derived in each product market[10]. The mechanical process described in section 4.1 is used to disaggregate chicken into white and dark meat.

Approximately 70% of chicken imports into Canada are white meat (AAFC, 2008), so enhanced market access would likely lead to increased flows of white (instead of dark) meat imports. If larger import volumes depress the domestic price of white meat, then domestic suppliers would respond by cutting quantity supplied. This would necessarily reduce dark meat production because white and dark chicken meat is produced and sold as a single product at the farm level. The reduction in dark meat supply could cause an increase in the price for dark meat. Also, since white and dark chicken meats are substitute products, lower white meat prices would decrease demand for dark meat.

5.3 Sensitivity Analysis

The parameters used in this research are taken from previous studies that use a range of different data sources and methodologies. We conduct sensitivity analyses to identify the most sensitive parameters used in the simulation model.

The discount rate is used to calculate the rental value of production quota, which is then used to estimate the marginal cost of Canadian chicken production in a perfectly competitive market. We simulate the model over a range of discount rates to evaluate how much more productive Canadian chicken producers would have to be for welfare to increase if enhanced market access increases the flow of imports into Canada.

We also conduct sensitivity analysis on the elasticity of chicken supply. The baseline supply elasticity is drawn from an estimate of US long-run broiler supply. Due to supply restrictions at the farm-level, Canadian chicken supply response may be more elastic than US supply response (Chavas, 1978). The supply functions (equations 5 and 8) are calibrated over a range of supply elasticities of 0.6, 0.8, and 1.0.

We also undertake a set of sensitivity analyses of the own- and cross-price elasticities of demand for white and dark meats to determine the sensitivity of our results to these parameter that are drawn from different sources (Goddard *et al.* 2007 and Thompson *et al.* 2008).

6.0 RESULTS AND DISCUSSION

The welfare effects of TRQ liberalization on the Canadian chicken market for the one-good model are displayed in table 3. The second column contains observed data that are used to calibrate the model and calculate baseline welfare measures against which liberalisation scenarios are compared. Column three presents the welfare results after simulating an increase in the volume of the import quota. The expansion of the import quota leads to a reduction in domestic supply by 10 million kg, and the resultant marginal cost and farm price fall from C$1.02 to C$1.00 and from C$1.64 to C$1.62 respectively. Owing to lower domestic prices and supply, producer surplus declines by C$21 million. The wholesale price of chicken decreases from C$2.95 to C$2.93, and domestic consumption increases by 4 million kg. The combination of lower prices and higher consumption generates an increase of C$28 million in consumer surplus. The net effect is a gain in welfare of C$7 million in the Canadian chicken market.

Increased market access would amplify the Canadian chicken market's exposure to world price volatility. Column four introduces price risk into the model, as defined by equation (8). The results in column four represent the baseline in which liberalisation has not taken place - these results are then compared to liberalisation scenarios that include price risk. The most notable difference between the two base scenarios (columns two and four) is the increase in marginal cost from C$1.02 to C$1.23. Under price risk, the supply function adjusted for the risk premium is steeper than without risk, leading to markedly higher marginal costs. Consumer surplus and processor revenue for the two base scenarios are the same. Producer surplus is lower when producers are risk averse and world price risk is introduced into the model. Import quota rents have higher values in the base scenario with price risk than in the base scenario without risk. The loss in producer surplus outweighs the gain in import quota rents; therefore, total welfare is lower with price risk than without.

The fifth column of table 3 reports the results of quota liberalization when world prices are stochastic and the farm-level supply function incorporates a risk premium. Import quota rents

increase due to the lower world price after liberalisation. The change in processor revenue and consumer surplus is the same for the two scenarios (with and without risk) because the risk premium does not affect the demand functions and because marketing margins are constant. A risk-normal simulation model is performed using the risk-analysis software @RISK to generate the 5th and 95th percentile values for the world price. Producer surplus fluctuates from C$609 million to C$1144 million, and consumer surplus varies from C$6270 million to C$4270 million. Processor revenue is not affected by price risk because of the assumption of constant processing costs. Note that if world prices approached $2.13, as indicated in the 5th percentile column, chicken imports would surge were it not for the prohibitively high over-quota tariff rate. Welfare in the chicken industry is affected by price risk, but the TRQ system provides insulation from volatile world prices.

Table 3: Welfare effects on the Canadian chicken market: one-good model

Variables	Base scenario	Quota Expansion	Risk Base scenario	Quota Expansion & Price Risk	5th	95th
Wholesale price	2.95	2.93	2.95	2.93	2.13	3.85
World price	1.93	1.93	1.89	1.75	0.94	2.66
Retail price	5.35	5.34	5.35	5.34	4.54	6.26
Farm price	1.64	1.62	1.64	1.62	1.21	1.83
Marginal cost	1.02	1.00	1.23	1.21	1.21	1.21
Consumption	941	945	941	945	945	739
Imports	73.1	86.5	73.1	86.5	86.5	0.00
Domestic Supply	868	858	868	858	858	858
Import quota rents	74	86	87	102	103	0.00
Producer surplus	1070	1051	981	964	609	1144
Processor revenue	1134	1121	1134	1121	792	1730
Consumer surplus	5866	5894	5866	5894	6270	4270
Total welfare	8145	8152	8069	8081	7775	7144

Prices: C$/kg eviscerated weight, Consumption, imports, and domestic supply: 000,000 kg; Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

We next calculate the water in the tariff (WIT) in order to determine if cuts to the over-quota tariff rate would affect chicken imports. The results of these calculations are found in table 4. We find that imports would only increase if the over-quota tariff is reduced by more than 182.66 percentage points (*i.e.* the new over quota tariff rate is lower than 55.34%) - any cut to over-quota tariff rates below that would leave landed prices uncompetitive. The latest DDA draft modalities (WTO, 2008) propose a cut of only 23.3%, which would bring the over-quota tariff rate down from 238% to 182%. This new over-quota tariff would still be prohibitive, which means that no imports over the minimum market access commitments would enter the Canadian market. Consequently, there is no liberalising effect due to the reduction of the over-quota tariff. The potential WIT, which is calculated with a counterfactual domestic wholesale price of chicken at the competitive level, tells us that if the over-quota tariff is reduced beyond 182.66 but less than 216.68 percentage points, then out-of-quota imports would not enter the Canadian market. However, domestic prices would have to be reduced towards competitive levels in order to render imports uncompetitive.

The NRP and the WIT are also calculated in the context of stochastic world prices. The 5th and 95th values are reported in table 4. A fall in the world price of chicken would allow out-of-quota imports into Canada if there were no WIT (*i.e.* the NRP and the over-quota tariff are equal). If the lower end of the probability distribution of the world price is below the domestic price, then an assumption about the marketing board production decision would have to be made (*e.g.* the marketing board could increase production to compensate for the loss associated with lower domestic prices). However, given that there is water in the over-quota tariff (even at the 5% level of the probability distribution), it is unlikely that the landed price would be below the domestic price. According to table 4, the current over-quota tariff has a WIT of 182.66%; therefore, flows of over access imports into Canada caused by a decrease in the world price are not anticipated. The only effect of tariff liberalisation is the reduction in the WIT. The new WIT and potential WIT after the over-quota tariff reduction are shown in table 4.

Table 4: Water and potential water in the tariff

	NRP	WIT	Potential NRP	Potential WIT
Over-quota tariff (238%)	55.34	182.66	21.32	216.68
Price risk	71.21	166.79	33.53	204.47
5 percentile	142.51	95.49	68.19	169.81
95 percentile	46.40	191.60	22.08	215.92
Over-quota tariff (182%)	55.34	127.21	21.32	161.22

All values in percent

The results of the simulation model after disaggregating chicken into two distinct products are presented in table 5. In the case of white chicken meat, the most significant difference between the baselines of the one-good model and the two-good model is the level of consumer surplus. The demand function for white meat is considerably steeper than the demand function for chicken (measured as a single product); as a result, consumer surplus is larger for white meat. Chicken is produced and sold as a single product at the farm level, and production is represented by a single supply function. Therefore producer surplus is the same in the two-good model as in the one-good model.

Larger flows of white meat imports pushes the domestic price of white meat down from C$4.91 to C$4.88, and consumption increases accordingly. Since white and dark meats are substitutes, consumption of dark meat decreases. Lower quantity supplied for dark meat as a result of lower domestic production increases its price from C$1.99 to C$2.00. The effect of quota liberalisation on processor revenue and consumer surplus is the same with or without price risk. However, producer surplus and import quota rents, as in the one-good case, are reduced by larger amounts when price risk is included in the model. The last two columns of table 5 report the 5th and 95th percentile values of the simulation model for stochastic world prices. Producer surplus fluctuates from C$336 million to C$643 million, and consumer surplus varies from C$8698 million to C$7853 million.

The demand function for dark meat is to the left of both the demand function for white meat and the demand function for chicken as an aggregated product. Therefore, consumer surplus for dark meat is smaller. Table 5 reports that quota liberalisation decreases consumer surplus for dark

meat from C$1454 million to C$1444 due to lower consumption. The overall welfare effect of quota liberalisation is negative for dark meat.

Table 5: Welfare effects on the Canadian chicken market: two-good model

Variables	Base Scenario	Quota Expansion	Risk Baseline	Quota Expansion & Price Risk	5th	95th
Wholesale price of white meat	4.91	4.88	4.91	4.88	3.32	6.31
Wholesale price of dark meat	1.99	2.00	1.99	2.00	1.26	2.73
World price of white meat	2.47	2.47	2.65	2.64	1.29	4.22
World price of dark meat	1.34	1.34	1.34	1.35	0.62	2.11
Retail price of white meat	14.83	14.8	14.8	14.8	13.2	16.2
Retail price of dark meat	4.54	4.55	4.54	4.55	3.81	5.28
White Meat						
Consumption	559	564	559	564	564	339
Imports	60.7	71.8	60.7	71.8	71.8	0.0
Domestic Supply	498	493	498	493	493	493
Import quota rents	148	173	138	161	30	0
Producer surplus	614	603	563	554	336	643
Processor revenue	1629	1602	1629	1602	1037	2206
Consumer surplus	8167	8258	8167	8258	8698	7853
Total welfare	10558	10637	10497	10575	10102	10702
Dark Meat						
Consumption	383	380	383	380.3	380.3	305
Imports	12.4	14.7	12.4	14.7	14.7	0.0
Domestic Supply	370	366	370	366	366	366
Import quota rents	8	10	8	9	9	0.0
Producer surplus	456	448	418	411	259	487
Processor revenue	132	138	132	138	17	327
Consumer surplus	1454	1444	1454	1444	1585	1305
Total welfare	2050	2039	2012	2002	1870	2120
Total for two-good model						
Consumption	941	945	941	945	945	644
Imports	73.1	86.5	73.1	86.5	86.5	0.0
Domestic Supply	868	858	868	858	858	858
Import quota rents	156	183	146	170	39	0.0
Producer surplus	1070	1051	981	964	596	1131
Processor revenue	1761	1740	1761	1740	1054	2533
Consumer surplus	9621	9701	9620	9701	10284	9158
Total welfare	12608	12675	12508	12576	11972	12822

Prices (C$/kg eviscerated); consumption, imports, and domestic supply (000,000 kg); producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare (C$ millions)

The aggregated results of the two-good model are presented in the bottom section of table 5 - these figures are calculated by adding the white and dark meat effects together. A comparison of the one-good model results to the two-good model results are in table 6. The second and third columns report the changes with respect to the base scenario, and the last two columns report the

changes with respect to the price-risk base scenario. Import quota rents increase in all cases after trade liberalisation due to the increase in imports and lower domestic prices, but the increase is higher in the two-good model due to a larger gap between the domestic and the world price of white meat. Producer surplus decreases in both models by the same amount, but the decrease is smaller when producers are risk averse than when they are risk neutral. The decrease in processor revenue is larger in the two-good model due to a larger fall of the domestic prices of white meat. Consumer surplus is significantly higher in the two-good model because of different white and dark meat demand functions. Trade liberalisation increases total welfare in both models, but the increase is larger when price risk is included in the model.

Table 6: Welfare effects: one-good model vs. two-good model

	Quota Expansion		**Quota Expansion & Price Risk**	
	One-good model	**Two-good model**	**One-good model**	**Two-good model**
Δ Import quota rents	12.28	26.32	14.67	24.41
Δ Producer surplus	-19.00	-19.00	-16.88	-16.88
Δ Processor revenue	-13.16	-20.98	-13.16	-20.98
Δ Consumer surplus	27.51	81.25	27.51	81.25
Δ Total welfare	7.63	67.59	12.14	67.80

All values are changes: C$ millions

6.1 Discussion of Results

We can draw a number of conclusions from the results of the simulations performed in this research. First, the current over-quota tariff rate is so high that DDA proposals to cut over-quota tariff rates would not enhance market access. The proposed 23.3% cut (for sensitive products using the two-thirds deviation formula) would leave a large amount of WIT, and there would be no liberalising effect. Even if world prices are modelled stochastically, it is unlikely that lower world prices could generate flows of out-of-quota imports into Canada. If the over-quota tariff is reduced beyond the WIT (currently 180%), but less than the potential WIT, then out-of-quota imports would not enter the Canadian market if domestic prices are reduced to approach competitive levels. Such a reduction in domestic prices could affect the Canadian chicken market, but is not modelled in this paper.

Second, estimated welfare implications are different between the model that treats chicken as a single product and the model that differentiates by cut. The Canadian chicken market is predominantly a white meat market, and most imports are white cuts. Consequently, an increase in the volume of low-priced foreign chicken imports would primarily affect the domestic wholesale price of white meat. The results of the welfare analysis show that there is a redistribution of welfare among import quota-rent holders, processors, and consumers between the two models. Therefore, the representation of chicken as differentiated products is an important consideration when modelling the Canadian chicken market. We view the model that disaggregates chicken by cut as more general and less restrictive (in that we do not impose the restriction that chicken is a single product), and therefore believe that the results from this model are more representative of potential trade liberalising effects.

One of the core objectives of a supply-managed system is price stability, so it is important to consider how liberalised trade would affect the industry's exposure to volatile world prices. Our results show that the liberalisation-induced welfare increase is larger when world prices are modelled stochastically. It is important to note that the risk premium used in this research may overstate the effects of price risk because it is derived from observations on relatively volatile world prices. The effects of world price fluctuations would only transmitted completely to Canadian producers if all tariffs are removed. However, imports are still subject to TRQs (although the import quota is expanded), and there is no trade liberalising effect due to over-quota tariff reduction. Domestic producers are insulated from domestic price volatility as long as there are trade barriers in place. The risk faced by Canadian producers is likely smaller than the estimates used in this research.

Current DDA proposals for liberalising the TRQs that currently protect Canada's chicken industry are modest. The reduction in the over-quota tariff would be small and the increase in market access would be relatively small. As a result, the overall welfare implications for Canada's chicken industry are modest. The welfare implications along the chicken supply chain can be briefly summarised as follows. The expansion of the import quota allows more low-priced imports of chicken products into Canada, thereby reducing domestic prices. Lower domestic prices induce consumption, and consumer surplus increases. Processors would experience two opposing effects of liberalisation: they would benefit from lower domestic prices and increased consumption, but processor revenue would decrease because production declines. Domestic supply is partially displaced by increased imports and producer surplus declines with liberalisation. The increase in consumer surplus and import quota rents outweighs the loss in producer surplus and processor revenue; as a result, total welfare increases. The overall welfare effects of trade liberalisation in Canada's chicken industry are positive.

Finally, the importance of the sensitive product designation cannot be overstated. Canada's supply-managed industries receive strong political support (House of Commons, 2009) and it appears as though Canada's chicken industry would be categorised as sensitive in the implementation of a DDA agreement. This means that the TRQs that limit Canadian imports would not be subjected to the same disciplines as other agricultural products. The simulations in this research are based on the modest disciplines that would be applied to sensitive products. If chicken were not to receive the sensitive product designation, then tariff rates would have to be cut substantially and market access would increase far beyond the scenarios in this research.

We conduct a range of sensitivity analyses on the parameters that form the foundation of the simulation model in this research. These parameters include the producer discount rates, the supply elasticity, and the own and cross price elasticities of demand for white and dark meats. The results of these analyses are presented in the appendix II. We provide just a brief explanation of the sensitivity analyses here.

Welfare measures are sensitive to the discount rate, which is used to estimate the marginal cost in a competitive market. Specifically, a lower initial marginal cost obtained with a higher discount rate significantly increases the level of producer surplus. A higher discount rate implies

higher productivity and suggests that the effects of trade liberalisation on Canadian producers would be smaller.

The effects of trade liberalisation on Canadian producers are smaller as their supply response increases because producers can adjust more easily to the increase of low-priced foreign chicken imports. However, a more elastic supply function decreases the base level of producer surplus and makes the difference between risk-neutral and risk-averse producers more significant. The sensitivity analysis with respect to the price elasticities of demand for white and dark meats demonstrates that a more inelastic demand for each type of meat increases the level of consumer surplus, thereby increasing total welfare (only the dark meat case is shown in the appendix II).

7.0 CONCLUDING REMARKS

Canada's chicken producers have relied on a system of TRQs to protect them from foreign competition since the implementation of the Uruguay Round Agreement on Agriculture in 1995. The current DDA negotiations include proposals that would reduce the level of protection that is provided by existing chicken TRQs. We develop a partial-equilibrium simulation model to evaluate the effects of current proposals on Canada's chicken industry.

Our simulations show that the effects of proposed TRQ liberalisation on Canada's chicken industry would be modest. Chicken is likely to be treated as a sensitive product in the implementation of a DDA agreement, and the required reforms to existing TRQs would not lead to large increases in chicken imports. The over-quota tariff would remain prohibitive after the proposed cuts, and the increase in the minimum access commitment would generate a small increase in imports. The net effects on the Canadian chicken market would be positive, with gains to consumers outweighing losses to producers.

Our results shed light on two methodological issues in modelling international trade of chicken. First, our simulation results are significantly different between models that do not account for price risk and models that do incorporate risk. The inclusion of price risk is particularly relevant when modelling supply-managed industries in which production and import controls are intended to reduce risk. Second, the disaggregation of chicken into two distinct products affects welfare measures of trade liberalisation. The disaggregation of chicken into two products relaxes the assumption of homogeneity across chicken cuts and leads to a less restrictive model. We believe that such disaggregation should be central to future chicken market analyses.

Notes

[1] $P_{wholesale}$ is the average, from 2004 to 2007, wholesale price of chicken (CFC 2009).

[2] Goddard *et al*. (2007).

[3] P_{white} and P_{dark} are the average, from 2004 to 2007, wholesale price of chicken breast and legs respectively (CFC 2009).

[4] The capitalization formula measures the ratio between the net operating income produced by an asset (rental value) and its capital cost (asset value).

[5] The discount rate is the producer's expected rate of return (or yield). Sensitivity analysis is conducted over a range of discount rates, based on the information of the 10-year period rates of return for poultry farms (AAFC, 2009).

[6] Based on one unit of production quota valued at C$57.63 (representing approximately 12 kg live weight of chicken), a conversion value of 0.738 between live and eviscerated weight (CFO 2007), and a discount rate of 10%, the rental value of production quota is C$0.65. Then, with a farm price of C$1.73 (converted to kg-eviscerated weight, CFC 2007), the marginal cost is C$1.08.

[7] The risk premium is the amount that a risk-averse producer is willing to pay as insurance against risk.

[8] Minimum market access is set at 7.5% of previous year's domestic production. Canadian chicken consumption (1036.9 million kg in 2007) is higher than Canadian chicken production (1003.6 million kg in 2007); therefore increasing the import quota level to 10% of previous year's domestic consumption would increase foreign access.

[9] A monopoly can only maximize profit in the elastic range of the demand function.

[10] In measuring the consumer surplus, for the two-good model, for a simultaneous change in prices, "path independence" cannot be assumed, i.e. the measure of the consumer's surplus will vary with the order in which the price changes are taken (Mishan E. J., 1977). However, the change in welfare due to price changes, maintaining income constant, is shown to be path independent and then a unique measure of consumer surplus is defined as the area under the demand curve and above the price (Chipman and Moore, 1976).

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Appendix I: Model Equations

Good	Variable	Variable Definition	Determination
Chicken	P	Wholesale price (C$/kg eviscerated)	$D - S - IM = 0$
Chicken	P_{world}	World price (C$/kg eviscerated)	*Exogenous*
Chicken	P_{farm}	Farm price (C$/kg eviscerated)	$P_{farm} = P - P_{margin}$
Chicken	Qr	Rental value of quota (C$/kg eviscerated)	$Qr = Qv * \lambda$
Chicken	Mc	Marginal cost (C$/kg eviscerated)	$Mc = P_{farm} - Qr$
Chicken	D	Consumption (000,000 kg)	$D = S + IM$
Chicken	IM	Imports (000,000 kg)	$IM = TRQ$
Chicken	S	Domestic Supply (000,000 kg)	$S = \alpha + \beta * Mc$
White meat	Pw	Wholesale price (C$/kg eviscerated)	$S_{white} - D_{white} - IM_{white} = 0$
White meat	P_{world}^{white}	World price (C$/kg eviscerated)	*Exogenous*
White meat	D_{white}	Consumption (000,000 kg)	$D_{white} = S_{white} + IM_{white}$
White meat	IM_{white}	Imports (000,000 kg)	$IM = Sh_{white} * TRQ$
White meat	S_{white}	Domestic Supply (000,000 kg)	$S_{white} = 0.533 * S$
Dark Meat	Pd	Wholesale price (C$/kg eviscerated)	$S_{dark} - D_{dark} - IM_{dark} = 0$
Dark Meat	P_{world}^{dark}	World price (C$/kg eviscerated)	*Exogenous*
Dark Meat	D_{dark}	Consumption (000,000 kg)	$D_{dark} = S_{dark} + IM_{dark}$
Dark Meat	IM_{dark}	Imports (000,000 kg)	$IM = Sh_{dark} * TRQ$
Dark Meat	S_{dark}	Domestic Supply (000,000 kg)	$S_{dark} = 0.467 * S$

Appendix II: Sensitivity Analysis

Table A1: Quota expansion: one-good model

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price	2.93	2.93	2.93	2.93	2.93	2.93
World price	1.93	1.93	1.93	1.93	1.93	1.93
Retail price	5.34	5.34	5.34	5.33	5.34	5.34
Farm price	1.63	1.62	1.62	1.62	1.62	1.63
Marginal cost	0.82	1.00	1.19	1.00	1.00	1.00
Consumption	944.2	944.7	945.1	945.4	944.7	944.2
Imports	86.5	86.5	86.5	86.5	86.5	86.5
Domestic Supply	857.7	858.2	858.6	858.9	858.2	857.7
Δ Producer revenue	-28.11	-29.16	-30.13	-30.86	-29.16	-28.01
Δ Import quota rents	12.47	12.28	12.11	11.99	12.28	12.48
Δ Producer surplus	-19.42	-19.00	-18.62	-21.48	-19.00	-17.31
Δ Processor revenue	-13.79	-13.16	-12.59	-12.16	-13.16	-13.84
Δ Consumer surplus	23.52	27.51	31.16	33.90	27.51	23.15
Δ Total welfare	2.77	7.63	12.07	12.24	7.63	4.48

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Table A2: Quota expansion and price risk: one-good model

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price	2.93	2.93	2.93	2.93	2.93	2.93
World price	1.75	1.75	1.75	1.75	1.75	1.75
Retail price	5.34	5.34	5.34	5.33	5.34	5.34
Farm price	1.63	1.62	1.62	1.62	1.62	1.63
Marginal cost	1.01	1.21	1.41	1.19	1.21	1.23
Consumption	944.2	944.67	945.11	945.44	944.67	944.2
Imports	86.5	86.5	86.5	86.5	86.5	86.5
Domestic Supply	857.7	858.17	858.61	858.94	858.17	857.7
Δ Producer revenue	-28.11	-29.16	-30.13	-30.86	-29.16	-28.01
Δ Import quota rents	14.85	14.67	14.50	14.37	14.67	14.87
Δ Producer surplus	-17.32	-16.88	-16.45	-19.67	-16.88	-14.87
Δ Processor revenue	-13.79	-13.16	-12.59	-12.16	-13.16	-13.84
Δ Consumer surplus	23.52	27.51	31.16	33.90	27.51	23.15
Δ Total welfare	7.26	12.14	16.62	16.44	12.14	9.30

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Table A3: Quota expansion: two-good model, white chicken meat

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price of white meat	4.88	4.88	4.88	4.87	4.88	4.88
Wholesale price of dark meat	2.00	2.00	2.00	2.00	2.00	2.00
World price of white meat	2.47	2.47	2.47	2.47	2.47	2.47
World price of dark meat	1.34	1.34	1.34	1.34	1.34	1.34
Retail price of white meat	14.80	14.80	14.80	14.80	14.80	14.80
Retail price of dark meat	4.55	4.55	4.55	4.55	4.55	4.56
Wholesale price of chicken	2.93	2.93	2.93	2.93	2.93	2.93
Retail price of chicken	5.34	5.34	5.34	5.33	5.34	5.34
Farm price of chicken	1.62	1.62	1.62	1.62	1.62	1.63
Marginal cost	0.82	1.00	1.19	1.00	1.00	1.00
Consumption	564.14	564.42	564.67	564.85	564.42	564.12
Imports	71.82	71.82	71.82	71.82	71.82	71.82
Domestic Supply	492.32	492.59	492.84	493.03	492.59	492.29
Δ Producer revenue	-15.67	-16.28	-16.84	-17.25	-16.28	-15.62
Δ Import quota rents	24.87	24.74	24.62	24.53	24.74	24.88
Δ Producer surplus	-10.80	-10.59	-10.40	-12.01	-10.59	-9.62
Δ Processor revenue	-27.95	-26.90	-25.94	-25.22	-26.90	-28.04
Δ Consumer surplus	86.59	91.12	95.27	98.37	91.12	86.17
Δ Total welfare	72.71	78.38	83.55	85.67	78.38	73.40

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Table A4: Quota expansion and price risk: two-good model, white chicken meat

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price of white meat	4.88	4.88	4.88	4.87	4.88	4.88
Wholesale price of dark meat	2.00	2.00	2.00	2.00	2.00	2.00
World price of white meat	2.64	2.64	2.64	2.65	2.65	2.64
World price of dark meat	1.35	1.35	1.35	1.34	1.34	1.34
Retail price of white meat	14.80	14.80	14.80	14.80	14.80	14.80
Retail price of dark meat	4.55	4.55	4.55	4.55	4.55	4.56
Wholesale price of chicken	2.93	2.93	2.93	2.93	2.93	2.93
Retail price of chicken	5.34	5.34	5.34	5.33	5.34	5.34
Farm price of chicken	1.63	1.62	1.62	1.62	1.62	1.63
Marginal cost	1.01	1.21	1.41	1.19	1.12	1.23
Consumption	564.14	564.42	564.67	564.85	564.42	564.12
Imports	71.82	71.82	71.82	71.82	71.82	71.82
Domestic Supply	492.32	492.59	492.84	493.03	492.59	492.29
Δ Producer revenue	-15.67	-16.28	-16.84	-17.25	-16.28	-15.62
Δ Import quota rents	23.00	22.87	22.75	22.66	22.87	23.01
Δ Producer surplus	-9.63	-9.40	-9.19	-11.00	-9.40	-8.25
Δ Processor revenue	-27.95	-26.90	-25.94	-25.22	-26.90	-28.04
Δ Consumer surplus	86.59	91.12	95.27	98.37	91.12	86.17
Δ Total welfare	72.01	77.69	82.89	84.81	77.69	72.89

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Table A5: Quota expansion: two-good model, dark chicken meat

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price of white meat	4.88	4.88	4.88	4.87	4.88	4.88
Wholesale price of dark meat	2.00	2.00	2.00	2.00	2.00	2.00
World price of white meat	2.47	2.47	2.47	2.47	2.47	2.47
World price of dark meat	1.34	1.34	1.34	1.34	1.34	1.34
Retail price of white meat	14.80	14.80	14.80	14.80	14.80	14.80
Retail price of dark meat	4.55	4.55	4.55	4.55	4.55	4.56
Wholesale price of chicken	2.93	2.93	2.93	2.93	2.93	2.93
Retail price of chicken	5.34	5.34	5.34	5.33	5.34	5.34
Farm price of chicken	1.62	1.62	1.62	1.62	1.62	1.63
Marginal cost	0.82	1.00	1.19	1.00	1.00	1.00
Consumption	380.05	380.26	380.44	380.58	380.26	380.03
Imports	14.68	14.68	14.68	14.68	14.68	14.68
Domestic Supply	365.38	365.58	365.77	365.91	365.58	365.36
Δ Producer revenue	-12.43	-12.88	-13.30	-13.61	-12.88	-12.39
Δ Import quota rents	1.60	1.58	1.56	1.55	1.58	1.61
Δ Producer surplus	-8.62	-8.41	-8.22	-9.47	-8.41	-7.69
Δ Processor revenue	5.62	5.92	6.19	6.39	5.92	5.59
Δ Consumer surplus	-10.94	-9.88	-8.90	-8.17	-9.88	-11.04
Δ Total welfare	-12.34	-10.79	-9.37	-9.70	-10.79	-11.53

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Table A6: Quota expansion and price risk: two-good model, dark chicken meat

Variables	Marginal Cost			Elasticity of Supply		
	0.83 C$/kg (13% disc. rate)	**1.02 C$/kg (10% disc. rate)**	**1.2 C$/kg (7% disc. rate)**	**0.6**	**0.8**	**1.0**
Wholesale price of white meat	4.88	4.88	4.88	4.87	4.88	4.88
Wholesale price of dark meat	2.00	2.00	2.00	2.00	2.00	2.00
World price of white meat	2.64	2.65	2.64	2.47	2.65	2.65
World price of dark meat	1.35	1.35	1.35	1.35	1.35	1.35
Retail price of white meat	14.80	14.80	14.80	14.80	14.80	14.80
Retail price of dark meat	4.55	4.55	4.55	4.55	4.55	4.56
Wholesale price of chicken	2.93	2.93	2.93	2.93	2.93	2.93
Retail price of chicken	5.34	5.34	5.34	5.33	5.34	5.34
Farm price of chicken	1.63	1.62	1.62	1.62	1.62	1.63
Marginal cost	1.01	1.12	1.41	1.19	1.12	1.23
Consumption	380.05	380.26	380.44	380.58	380.26	380.03
Imports	14.68	14.68	14.68	14.68	14.68	14.68
Domestic Supply	365.38	365.58	365.77	365.91	365.58	365.36
Δ Producer revenue	-12.43	-12.88	-13.30	-13.61	-12.88	-12.39
Δ Import quota rents	1.56	1.54	1.52	1.50	1.54	1.56
Δ Producer surplus	-7.70	-7.48	-7.27	-8.67	-7.48	-6.62
Δ Processor revenue	5.62	5.92	6.19	6.39	5.92	5.59
Δ Consumer surplus	-10.94	-9.88	-8.90	-8.17	-9.88	-11.04
Δ Total welfare	-11.46	-9.90	-8.46	-8.94	-9.90	-10.50

Prices: C$/kg eviscerated weight
Consumption, imports, and domestic supply: 000,000 kg
Producer revenue, import quota rents, producer surplus, processor revenue, consumer surplus, and total welfare: C$ millions

Figure A1: Sensitivity analysis on demand elasticities. Quota expansion and price risk: two-good model, dark chicken meat