"Reflections on a Career as an Industrial Organization and International Economist"

Ian M. Sheldon

Andersons Chair of Agricultural Marketing, Trade, and Policy

Department of Agricultural, Environmental, and Development Economics,

Ohio State University

Corresponding author email address: sheldon.1@osu.edu

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Abstract

In this article, I reflect on my career in the agricultural economics profession as a researcher who has focused predominantly on the synthesis of two fields in economics: industrial organization and international trade. In that context, I consider my main contribution to have been in analyzing the impact of public policy where imperfect competition matters in the food and agricultural marketing system, be it in either the horizontal or vertical market dimensions. In addition, I have also paid considerable attention to incorporating market structure into empirical analysis of food and agricultural trade.

Introduction

When the editor of the journal invited me to write an overview of the findings of my career, my initial thought was where do I start? This question arose not because of the volume of what I have written, which is not huge, but more because of a sense that I have jumped from topic to topic as opposed to developing a highly specialized body of work. This most likely reflects that I am both a voracious consumer of others' published economics research, as well as having a propensity to get rather quickly bored with a specific topic of research! For the record, I have published articles analyzing, *inter alia*, futures markets, product licensing, the fertilizer and aluminum industries, contracting, tariff-rate quotas (TRQs), exchange rates, food safety and labeling, regulation of biotechnology, intellectual property rights, trade and product quality, and most recently economic nationalism.

However, in looking back, one constant has been my focus on two fields in economics: industrial organization and international economics, and especially their interaction. This not only reflects my graduate training and meeting a like-minded researcher in Steve McCorriston at the University of Exeter at a formative stage in my career, but also the fact that over the past 40 years, both fields have been very dynamic. First, industrial organization, which was historically very empirical in its use of the structure-conduct-performance (SCP) framework of Bain (1956), came under considerable theoretical scrutiny via the so-called "new industrial organization" (NIO) (Jacquemin 1987), culminating with the publication of Tirole's (1989) now-standard text. In turn, this shift to theory, stimulated the development and application of structural econometric tools described as the "new empirical industrial organization" (NEIO) (Bresnahan, 1989). [1] Second, and parallel to this, international economics has been transformed from a field where, international economists were, in the words of Richard Caves,

> "…steadfast in their devotion to pure competition as a theoretical market form …" (Caves 1985, p.377)

to one where the empirical gravity model, with its "dubious theoretical heritage" (Deardorff, 1984, p.503), has been shown theoretically to hold under a broad spectrum of market structures (Costinot and Rodríguez-Clare 2014).

It is probably true to say that I started out my career as an industrial organization economist who paid some attention to the impact of trade on competition, who then shifted to thinking about how industrial organization might affect the outcome of various trade policy choices, and as I reach the end of my career, I am now morphing into an international economist mostly concerned with legal issues related to the governance of the global trading system. It is in this context that I offer an overview and evaluation of the body of research I have produced over my nearly 40-year career. Specifically: the first section provides some background to my graduate training, and what initially interested me as an industrial organization economist; the second section focuses on what I consider to be my main contributions to thinking about the impact of imperfectly competitive market structures on policy outcomes; while the third section describes and evaluates some of the empirical work I have conducted over the years using some version of the gravity model; I conclude in a final section with some thoughts about the future of agricultural economics research at the intersection of trade and industrial organization.

Industrial Organization Economist

Structure-Conduct-Performance

As an undergraduate at the University of Salford in the United Kingdom, I took one class in industrial organization with a professor, Anthony Cockerill, who subsequently became one of my PhD co-advisers. It is only now that I publicly admit to the fact that, instead of studying hard for the final exam in this subject, I actually chose to watch virtually all of the games in the 1978 World

Cup from Argentina – despite England not qualifying for the tournament!! No matter, I still passed the exam, and upon graduation, I was most fortunate that Dr. Cockerill offered me three years of graduate funding at Salford which I readily accepted.

The focus of my PhD research, heavily influenced by my other adviser, Dr. Derrick Ball a chemical engineer with an MBA, was an industrial organization analysis of the process plant contracting industry. This industry consists of firms that design, engineer and construct large processing plants in the oil refining and chemicals sector. Given Dr. Cockerill's background in analyzing various UK industries such as steel and brewing, my research was heavily influenced by Frederic Scherer's (1970) classic textbook on market structure and performance, which was strongly rooted in the empirical tradition of industrial organization pioneered by Mason (1939) at Harvard, and applied by his student Bain (1951; 1956). Essentially, my dissertation was a description and empirical analysis of the structure, conduct and performance of a specific industry, with specific focus on measuring the extent of economies of scale. This led, not surprisingly, to a rather descriptive article being published (Sheldon, Cockerill, and Ball 1984). Having said that, I learned the importance of carefully looking at a specific sector as a pre-cursor to thinking about it analytically – something I do to this day and would recommend young industrial organization researchers to do as well, going beyond a set of "stylized facts".

Industrial Organization and Trade

Given that my PhD research was a very detailed case-study of one industry, I was unable to conduct the then typical cross-sectional empirical research in industrial organization pioneered by Bain (1951), where average accounting profits Π_i in the i^{th} industry would be regressed on seller concentration S_i in that industry:

$$\Pi_i = \mathrm{A}_i + \beta S_i, \qquad (1)$$

a positive coefficient on market structure being taken to mean that higher seller concentration facilitated collusion among firms, and therefore higher industry profits, A_i representing all other factors affecting industry profitability (Geroski 1988).[2]

However, I did get drawn into doing this type of research during my post-doctoral work at the University of Manchester Institute of Science and Technology (UMIST). I was hired to help Professor John Pickering revise his textbook (Pickering 1974), but when this did not go to plan, we worked on a paper focusing on trade and industrial organization. At the time of writing, some empirical SCP research had related a measure of industry profits to various measures of foreign competition, most providing support for the hypothesis that imports may restrict the exercise of market power (Jacquemin 1982). The late Emilio Pagoulatos, who I consider one of my key early mentors in the US, published several articles with Robert Sorenson relating to this hypothesis (Pagoulatos and Sorenson 1976; 1979).

In my research with Pickering, we took a slightly different tack, the trade performance of a cross-section of 97 British industries being regressed on an index of market structure over the time-period 1970-77, the results indicating that poor trade performance was associated with high seller concentration. Although the research was eventually published (Pickering and Sheldon 1984), being told at a seminar by luminaries of the then University of Warwick industrial organization group that it was extremely *ad hoc*, alerted me to Cowling and Waterson's (1976) effort to provide a theoretical underpinning to SCP models, as well as the growing criticism of the related empirical literature.[3]

In particular, by adding international trade to the model, Lyons (1981) was able to show that firm profitability and import penetration are co-determined, i.e., it is impossible to infer any direction of causality between performance and market structure.[4] Suppose there are *n* domestic

firms operating in the market, each with constant marginal costs of c, and there are m foreign firms that can provide imports at constant marginal cost tc, where $t > 1$ are trading costs such as an import tariff. Firms maximize their profits subject to how they "conjecture" their rivals will react, their beliefs being captured by the parameter α, which indexes the fixed proportionate reaction of rival firms' output x_j to a proportionate change in one firm's output x_i,

$$\frac{dx_j}{dx_i} = \alpha \frac{x_j}{x_i} \text{ for all } j \neq i \text{ and for all } i. \tag{2}$$

If firms are playing a Cournot-Nash game, $\alpha = 0$, while $0 < \alpha < 1$ represents some degree of implicit collusion between firms. The aggregated first-order condition for domestic firms is:

$$\frac{p-c}{p} = \frac{1}{\eta}\left\{\frac{1-\alpha}{n} + \alpha - s\left[\frac{1-\alpha}{n}\right]\right\}, \tag{3}$$

where p is industry price, η is the constant and positive-signed price elasticity of demand, and s is the share of imports in the domestic market. Following Jacquemin (1982), expression (3) can be interpreted as an extended Lerner index of market power for domestic firms in the presence of import competition. Similarly, the aggregated and rearranged first-order condition for foreign firms is:

$$s = \frac{m}{1-\alpha}\left\{\eta\left[\frac{p-tc}{p} - \alpha\right]\right\}. \tag{4}$$

Examination of (3) suggests that there is a theoretical argument for regressing the industry price-cost margin on variables capturing market structure and the share of imports in the domestic market. However, equation (4) indicates that the share of imports in the domestic market is also a function of the industry price-cost margin, i.e., both (3) and (4) are functions of the key parameters: n and m, η, α, and t., i.e., no specific inferences can be drawn from any observed correlation between price-cost margins and import penetration because they are simultaneously determined.

For example, a reduction in trade costs can have a competitive effect on domestic firms' price-cost margins, but at the same time the share of imports will increase, the extent being contingent on both market structure and the behavior of firms.

At the time I read Lyons' (1981) article, along with others by Jacquemin, de Ghellink, and Huveneers (1980), Geroski and Jacquemin (1981), and Jacquemin (1982), it was not totally obvious to me how important their contribution was to making a rigorous connection between industrial organization and international trade. However, with the benefit of hindsight, I can see that many of their ideas were a pre-cursor to the type of model employed in the literature on imperfect competition and trade policy.[5] In addition, Cowling and Waterson's (1976) model and its derivatives, was an important link between the SCP paradigm and what would become the NEIO.

The only thing missing from this framework was some discussion of the impact of imperfect competition on passthrough of policy changes such as a reduction in tariffs. Although this did get incorporated into the later literature on pricing to market (Krugman 1987), and exchange rate passthrough (Feinberg 1989; Knetter 1989; 1993), with specific applications in the food and agricultural sector (Pick and Park 1991; Pick and Carter 1994).[6] Passthrough also became a key part of my own research agenda when thinking about vertical market structure, but more of that later.

Industrial Organization and International Economist

Switching to Agricultural Economics

After completing my post-doctoral research, I was hired as a temporary lecturer in industrial organization and applied welfare economics at the University of Exeter in 1982, apparently because I knew something about modeling imperfect competition. This subsequently turned into

a position as a permanent lecturer in agricultural economics in 1983, despite my having no background whatsoever in the field! I was actually very fortunate that Professor John McInerney, the then Chair of the Agricultural Economics Unit, was interested in seeing more research and teaching conducted on the UK food marketing system, and he encouraged me to apply my industrial organization skills to that sector.[7]

My first foray into agricultural economics research concerned futures markets, focusing on the London Meat Futures Exchange which had opened in 1984. Despite my publishing two articles analyzing this market (Sheldon 1986; 1987), and thereby establishing my credentials as an agricultural economist, my colleagues who were finance economists at the University of Exeter politely convinced me that thinking about efficient markets and rational expectations was probably not my comparative advantage – advice for which I remain very grateful. It was also at this point that my career-long collaboration with Steve McCorriston began in earnest. His training and focus were related more to international economics, but with the growing integration of industrial organization into trade models, the timing was perfect for us to work jointly in that area, applying ideas from this new literature to the food and related industries.

Strategic Trade Theory and The Food and Related Industries

As noted by Jacquemin (1982) and Caves (1985) in their respective surveys of the literature, it was not until the late-1970s/early-1980s that trade economists really began to incorporate imperfect competition into international economic models. What became known as the "new trade theory" is mostly associated with two key analytical developments. First, monopolistic competition was embedded into general equilibrium trade models in seminal articles by, *inter alia*, Krugman (1980) and Helpman (1981), and subsequently synthesized in their influential text (Helpman and Krugman 1985). Second, oligopoly models were used to explain "reciprocal

dumping" and intra-industry trade in homogeneous goods (Brander 1981; Brander and Krugman 1983), and also to analyze trade and other policy options in the presence of imperfect competition, an area of the literature that became known as "strategic trade theory".[8]

Although we dabbled in some initial empirical analysis of intra-industry trade (McCorriston and Sheldon 1989a), I think it is true to say that we dove head first into strategic trade theory, which has subsequently had a lasting impact on our academic output over the years. I consider myself very fortunate to have read two seminal articles at this time: Brander and Spencer (1985), and Eaton and Grossman (1986).[9] The fundamental results of strategic trade theory can be characterized in terms of non-cooperative, static and simultaneous move games in the sense that agents (firms and policymakers) do not coordinate their actions, the game is played once, and agents make their moves at the same time. A critical feature of the analysis though is that one class of agent, the policymaker, can make a move before other agents, which introduces the notion of pre-commitments. To fix ideas, I sketch a downstream duopoly model that McCorriston and I used in our later research on vertical market structures (Sheldon, Pick, and McCorriston 2001; McCorriston and Sheldon 2005a; 2011).

Let x_1 equal the output choice of a domestic firm and x_2 the output choice of a foreign firm. Their revenue functions can be written as:

$$R_1(x_1, x_2) \tag{5}$$

$$R_2(x_1, x_2). \tag{6}$$

Downward sloping demands and substitute goods are assumed.

Given (7) and (8), the relevant profit functions are given as:

$$\pi_1 = R_1(x_1, x_2) - x_1(c_1 + z_1) \tag{7}$$

$$\pi_2 = R_2(x_1, x_2) - x_2(c_2 + z_2), \tag{8}$$

where c_1 and c_2 are the domestic and foreign downstream firms' respective marginal costs, and z_1 and z_2 are policy instruments such as export subsidies (tariffs) that can be targeted at firms by either the domestic and/or the foreign policymaker.

The first-order conditions for profit maximization are given as:

$$R_{1,1} = c_1 + z_1 \tag{9}$$

$$R_{2,2} = c_2 + z_2. \tag{10}$$

Duopoly equilibrium is derived by totally differentiating the first-order conditions (9) and (10):

$$\begin{bmatrix} R_{1,11} & R_{1,12} \\ R_{2,21} & R_{2,22} \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} dc_1 + dz_1 \\ dc_2 + dz_2 \end{bmatrix}. \tag{11}$$

The slopes of the reaction functions are found by implicitly differentiating firms' first-order conditions:

$$\frac{dx_1}{dx_2} = r_1 = -\frac{R_{1,12}}{R_{1,11}} \tag{12}$$

$$\frac{dx_2}{dx_1} = r_2 = -\frac{R_{2,21}}{R_{2,22}}. \tag{13}$$

With this set-up, it is possible to deal with both strategic substitutes and strategic complements where the variable of interest is the cross-partial effect on marginal profitability, that is sign r_i = sign $R_{i,ij}$. Consequently, with reference to equations (12) and (13), if $R_{i,ij} < 0$, then $r_i < 0$, i.e., goods are strategic substitutes, the reaction functions being downward sloping. However, if $R_{i,ij} > 0$, then $r_i > 0$, reaction functions being upward sloping and goods are strategic complements. The distinction between strategic substitutes/complements relates to the "aggressiveness" of firms' strategies (Bulow, Geanakopolos and Klemperer 1985), and is a way

of capturing different duopolistic behavior, i.e., Cournot vs. Bertrand, in output space. Whether goods are strategic substitutes or complements depends on the second derivatives of the demand function.

Given (11), the solution to the system is found by re-arranging in terms of dx_i and inverting where Δ is the determinant of the left-hand side of (11):

$$\begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \mathbf{\Delta}^{-1} \begin{bmatrix} R_{2,22} & -R_{1,12} \\ -R_{2,21} & R_{1,11} \end{bmatrix} \begin{bmatrix} dc_1 + dz_1 \\ dc_2 + di_2 \end{bmatrix}. \tag{14}$$

To simplify the notation (14) can be re-written as:

$$\begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \mathbf{\Delta}^{-1} \begin{bmatrix} a_2 & a_1 r_1 \\ a_2 r_2 & a_1 \end{bmatrix} \begin{bmatrix} dc_1 + dz_1 \\ dc_2 + dz_2 \end{bmatrix}, \tag{15}$$

where $a_1 = R_{1,11}$, and $a_2 = R_{2,22}$. For stability of the duopoly equilibrium, the diagonal of the matrix has to be negative, i.e., $a_i < 0$, and the determinant positive, $\mathbf{\Delta}^{-1} = a_1 a_2 (1 - r_1 r_2) > 0$.

The basic idea of strategic trade policy is captured in (15). A credible pre-commitment to a specific policy instrument by either or both countries will affect the duopoly equilibrium. Drawing on Brander and Spencer (1985), suppose both firms are competing against each other in the world market, and goods are strategic substitutes. If the domestic policymaker offers a per unit export subsidy, the domestic firm can credibly increase its output at the expense of the foreign firm. Specifically, from (15), for the domestic firm, $dx_1 = \Delta^{-1} a_2 dz_1$, and since $\Delta^{-1} > 0, a_2 < 0$, and $dz_1 < 0$, then $dx_1 > 0$, while for the foreign firm, $dx_2 = \Delta^{-1} a_2 r_2 dz_1$, and since $\Delta^{-1} > 0, a_2 < 0$, $r_2 < 0$, and $dz_1 < 0$, then $dx_2 < 0$. It is easy to show that these output changes will shift profits from the foreign to the domestic firm – the essence of strategic trade theory.

This very stark result seems to provide a simple case for government intervention in imperfectly competitive markets. However, as pointed out by Eaton and Grossman (1986), the

argument for an export subsidy depends critically on goods being strategic substitutes (Cournot). If instead goods are strategic complements, a per unit export subsidy will increase the output of both firms, thereby lowering both firms' profits, i.e., the foreign firm acts more aggressively with respect to an increase in output of the domestic firm (Bertrand). The implication is that, in this case, the domestic policymaker should tax the exports of its own firm.

The sensitivity of the Brander and Spencer (1985) result to the game being played by firms, along with several other well-merited criticisms (Grossman 1986), suggest that a good deal of care should be taken in implementing strategic trade policy.[10] However, wearing my industrial organization hat, I would argue that this perhaps misses the point – even if the objective of applying this type of analysis is not to promote government intervention, it is important for agricultural economists to properly model imperfect competition when analyzing trade and other policies affecting the food and related industries, where the relevant market clearly has the potential to be less than competitive (McCorriston and Sheldon 1994a).[11] Having said that, the stripped down model just presented, while very useful in generating clear comparative statics for the impact of trade policy(ies), is too restrictive for conducting any type of empirical analysis. Looking back at Lyons' (1981), the model outlined ignores several aspects of market structure, as well as the potential for a wider range of market conduct. This suggests that theoretical purity should perhaps be sacrificed in favor of a more specific model where the core idea(s) of strategic trade theory are still captured.

Shortly after Brander and Spencer's (1985) article was published, Dixit (1987; 1988) provided McCorriston and myself with the perfect vehicle for our initial applied work on trade policy and imperfect competition in the UK fertilizer industry.[12] We actually published three connected articles on this industry (McCorriston and Sheldon 1989c; 1991a; 1993), but I refer here to the

latter article, not only because it took the longest to get published, but I like to think it was the basis for me getting a visiting faculty position at Ohio State University in 1989![13]

In the late-1980s, the UK fertilizer industry was characterized by a few large-scale firms exploiting scale economies, three firms accounting for 80 percent of market share in 1987, the remainder of the market being captured by a fringe of smaller blending firms who imported nitrogen fertilizers. For many years, oligopolistic accommodation characterized the industry, but this was undermined in 1986 by a significant increase in cheap imports of urea, a nitrogen substitute, especially from the then Eastern Bloc. As a result, the dominant firms complained of dumping to both the UK government and the European Community (EC). In response, in 1987 the UK government implemented quotas on urea imports, while the EC applied a minimum import price. The key objective of the research was to evaluate these policies relative to what would have been optimal.

Dixit's (1987) model is essentially an NIO-type, that assumes linear demand with differentiated products, and firm behavior modeled as conjectural variations. The inverse derived demand functions for fertilizers in the UK are:

$$p_1 = a_1 - b_1 X_1 - k X_2 \tag{16}$$

$$p_2 = a_2 - k X_1 - b_2 X_2 , \tag{17}$$

where p_1, p_2, X_1 and X_2 are the prices and aggregate quantities sold by the dominant and blending firm respectively, with all parameters being positive, and $b_1 b_2 - k^2 \geq 0$.

On the supply side, there are n_1 and n_2 symmetric dominant and blending firms, where the profit functions of a typical firm in either sector is:

$$\pi_1 = (p_1 - c_1)x_1 \tag{18}$$

$$\pi_2 = (p_2 - c_2)x_2, \tag{19}$$

where p_1, p_2, x_1 and x_2, c_1 and c_2 are their respective prices, quantities, and costs.

Following Dixit (1988), firm behavior is modeled as a Nash equilibrium in conjectural variations, where the conjectures are denoted as v_{ij}, where $i, j = 1, 2$, interpreted as the amount by which each firm *i* believes each other firm *j* will respond to a variation in its output, $\partial x_j / \partial x_i, i \neq j$. For example, a representative dominant firm expects that, if it changes its output, other dominant firms' output will change by $1 + (n_1 - 1)v_{11}$, and blending firms' output will change by $n_2 v_{12}$. With Cournot behavior, all v_{ii}'s will equal zero, and in the limit, they are bounded at $v_{ii} = -1$ for the competitive outcome, and $v_{ii} = 1$ for the collusive outcome.

If firms maximize profits with respect to output, the first-order conditions for representative dominant and blending firms are:

$$p_1 - c_1 + x_1\left[\frac{\delta p_1}{\delta X_1}(1 + (n_1 - 1)v_{11} + \frac{\delta p_1}{\delta X_2} n_2 v_{12}\right] = 0 \tag{20}$$

$$p_2 - c_2 + x_2\left[\frac{\delta p_2}{\delta X_2}(1 + (n_2 - 1)v_{22} + \frac{\delta p_2}{\delta X_1} n_1 v_{21}\right] = 0, \tag{21}$$

If aggregate versions of the conjectural variation parameters are defined as:

$$\lambda_1 = \left[b_1\{1 + (n_1 - 1)v_{11}\} + k n_2 v_{12}\right] / n_1 \tag{22}$$

$$\lambda_2 = \left[b_2\{1 + (n_2 - 1)v_{22}\} + k n_1 v_{21}\right] / n_2, \tag{23}$$

(20 and (21) can be re-written as:

$$p_1 - c_1 - X_1\lambda_1 = 0 \tag{24}$$

$$p_2 - c_2 - X_2\lambda_2 = 0. \tag{25}$$

With relevant data, values for the λ_i can be retrieved from (24) and (25), and compared to the cases of Cournot, $\lambda_i = b_i / n_i$, and competition, $\lambda_i = 0$. Of course, game theorists argue against using conjectural variations, the standard objections being that *ad hoc* consistency conditions have to be imposed (Bresnahan 1981), and they represent an attempt to impose dynamic interactions on a single-period game (Tirole 1989).[14] Therefore, in the NEIO literature, it became common to interpret them as the industry markup of price over marginal cost, i.e., an index of market power (Perloff 1992; Sheldon and Sperling 2003).

Using the inverse demand functions (16) and (17), (24) and (25) can be re-written as:

$$(a_1 - c_1) - (b_1 + \lambda_1)X_1 - kX_2 = 0 \tag{24'}$$

$$(a_2 - c_2) - (b_2 + \lambda_2)X_2 - kX_1 = 0\,. \tag{25'}$$

Totally differentiating (24') and (25') and rearranging gives:

$$\begin{bmatrix} dX_1 \\ dX_2 \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} (b_2 + \lambda_2) & -k \\ -k & (b_1 + \lambda_1) \end{bmatrix}\begin{bmatrix} -dc_1 \\ -dc_2 \end{bmatrix}, \tag{26}$$

where $\Delta = \{(b_1 + \lambda_1)(b_2 + \lambda_2) - k^2\} > 0$. Equation (26) is the *n*-firm, conjectural variations version of (15), the Brander and Spencer (1985) result holding if firms have Cournot conjectures, i.e., if costs are shocked by some policy *z*, $dX_1 = \Delta^{-1}(b_2 + \{b_2 / n_2\})dc_1 > 0$, and $dX_2 = \Delta^{-1} - kdc_1 < 0$.

The beauty of this model was that it could be calibrated to data and then used for counterfactual policy simulation.[15] With respect to the UK fertilizer industry we evaluated the EC's minimum import price and the UK's import quota by comparing them respectively to an optimal tariff and the import restriction that would have been consistent with the tariff-induced outcome.[16] Importantly, following Hwang and Mai (1988), a quota restriction effectively imposed Cournot behavior on the dominant firms, i.e., the latter know that if they changed their output, the blending firms' output could not change if the quota was binding. In other words, if the dominant

firms' conjectures were more (less) competitive than Cournot, the effect of the quota would have been to raise (lower) their prices relative to those that would have prevailed with tariffs. The results of the calibration indicated that the UK import quota was considerably more restrictive than the tariff-equivalent quota, while the EC minimum import price was slightly less restrictive than the optimal tariff. Simulation of the welfare effects indicated that a tariff would have been preferable to an import quota, given that the market was initially more competitive than Cournot.[17]

Having figured out how to get this model to work, it was hard not to resist using it on other food and related markets other than fertilizers. At this point in my career, I think it is fair to say that I went slightly "bananas" for a while – pun intended! Interest in the banana sector was based on reforms to the EC's banana import regime introduced in 1993, and the fact that the world banana export industry at that time was dominated by three US multinational firms, United Brands (Chiquita), Standard Fruit (Dole), and Del Monte, who accounted for 70 percent of the world market and 66 percent of the European market. In McCorriston and Sheldon (1996a), the focus was on the German banana import market where three firms, United Brands, Standard Fruit, and Noboa, accounted for 72 percent of the market.[18]

Prior to the July 1993, Germany operated a regime of free trade in bananas, while countries such as France, Spain, and the UK maintained import restrictions on imports from the so-called "Dollar" countries, e.g., Colombia and Ecuador, in order to ensure high prices for suppliers of bananas from their former colonies in Africa, the Caribbean, and Pacific (ACP). As a result, there was wide variation in retail banana prices across the EC, which were inconsistent with the 1992 Single Market process. The border policy implemented by the EC was quite complex, but essentially consisted of a combination of levies and quotas. Given that Germany had been importing 1.35 million metric tons of bananas from the Dollar area, and the new EC import regime

imposed a levy on any Dollar area imports, in excess of 2 million metric tons, Germany effectively faced a binding import quota, the levy capturing the quota rents.

Using the calibrated simulation model already outlined, we evaluated the welfare effects of the EC import regime on the German banana market. Compared to the baseline of free trade, and given that both the dominant and fringe banana exporting firms were initially playing more competitively than Cournot, imposition of the levy-quota scheme resulted in a significant welfare loss, both sets of firms playing less competitively as a result of the quota, generating a significant loss to German consumers, the levy only capturing part of the quota rents earned by the banana exporting firms.[19]

As an aside, while "going bananas" a graduate student and I found that the firms operating in the German banana import market were competing very close to the Cournot outcome (Deodhar and Sheldon 1995; 1996).[20] While this suggests that welfare losses from the EC banana import regime were probably somewhat lower than those we reported in McCorriston and Sheldon (1996a), the results of this research emphasized the need for careful empirical evaluation of the extent of imperfect competition in food and agricultural markets when analyzing policy.

In evaluating this particular segment of my career, I think focusing on the effect of import quotas was an important contribution to the literature on strategic trade policy, and the articles I published with McCorriston on this really benefited from a wide reading of international economic analysis on the non-equivalence of tariffs and quotas.[21] Prior to incorporating this comparison of policy instruments into the Dixit (1987; 1988) oligopoly framework, McCorriston and I spent some time thinking about reform of the EC's Common Agricultural Policy (CAP) in the presence of imperfect competition. Efforts by the EC to reduce agricultural production often operated through firms in the food processing sector facing restraints on their processing capacity for commodities

such as sugar. In this sense, CAP reform had the potential to "facilitate" collusive practices in food processing.

With this motivation, we incorporated the ideas of Fung (1989) and Krishna (1989) into a duopoly framework, where domestic and foreign-owned processing firms compete in the domestic market, the former processing a domestically supplied agricultural commodity, the latter processing an imported agricultural commodity (McCorriston and Sheldon 1992). We found that if one firms' capacity is constrained, profits are shifted to the other under quantity competition (strategic substitutes), while both benefit under price competition (strategic complements). If both firms face capacity constraints, each firm will benefit, whatever the nature of competition. In other words, food processing firms may well have benefited from CAP reform, while consumers would have unambiguously lost out through higher prices for processed good.

Modeling Vertical Market Structures

Given the vertical nature of the food and related industries, it was probably inevitable that my interest in the effects of policy in the presence of imperfect competition would shift to thinking about this in a vertical market setting. Necessarily as an industrial organization economist, I had been exposed in my training to analysis of vertical market structures, especially the welfare effects of vertical integration between firms at different stages of the production chain, notably the classic article by Vernon and Graham (1971). In addition, my interest in the NIO literature due to Cowling and Waterson (1976) led me to the latter author's extension of Cournot's classic discussion of zinc and copper monopolists selling to a competitive brass industry, where the copper firm vertically integrates with the brass industry (Waterson, 1980). The key idea in this article was to link the price-cost margin of the zinc industry with the integrated vertical sector (copper and brass), generating the surprising result that the zinc industry's price-cost margin was a positive function

of the extent of market power in the integrated sector, assuming the latter has no monopsony market power.

The underlying issue in Waterson (1980) and many subsequent articles on vertical structure, is the market failure due to "double marginalization" highlighted originally by Spengler (1950).[22] Specifically, there is an inefficiency when firms at successive stages of a market chain independently mark up prices over marginal cost. Importantly, this inefficiency can be internalized either through vertical integration or the use vertical restraints such as resale price maintenance, full line forcing, exclusive territories and retail slotting fees. Specifically, contracts between manufacturers and retailers, a class of the principal-agent problem, can be written in such a way as to remove a markup, thereby maximizing the total amount of profits to be shared between the vertical stages (Katz 1989).

Much of the research on vertical coordination in the food marketing chain was initially quite descriptive, but in line with theoretical developments in the industrial organization literature, careful analysis of vertical contractual relationships in the sector has grown almost exponentially.[23] As I note in my own extensive review of this literature (Sheldon 2017), the research emphasis in the US as compared to the European Union (EU) has been somewhat different, reflecting different market power concerns along their respective marketing chains, and, therefore, who is principal and who is agent in the relationship The research and policy focus in the US has been more on the nature of contractual relationships between agricultural producers (agents) and processors (principals), reflecting public concern over processors exerting market power (Crespi, Sexton, and Saitone 2012; Sexton, 2013). In contrast, policy and research in the EU has focused much more on contractual relationships between food processors (principals *vs*. agents) and retailers (principals *vs*. agents), reflecting widespread concern in Europe over both retailer market power

as well as incomplete transmission (passthrough) of price changes from the agricultural sector to the consumer (McCorriston 2002; 2014; Lloyd, McCorriston, and Morgan 2015).

Overall, these two very rich strands of literature have contributed enormously to our understanding of a wide range of vertical market issues, including, *inter alia*: broiler production contracts (Goodhue 2000), relational contracting (Wu 2006), slotting fees (Innes and Hamilton 2006), network externalities in food retailing (Richards and Hamilton 2013), retail bargaining power (Bonnet and Boumra-Mechemache 2016), and non-linear wholesale pricing (Bonnet, Dubois, Villas Boas, and Klapper 2013).

My own interest in vertical market coordination derived from reading early extensions of the strategic trade policy literature to thinking about trade in intermediate and final goods (Spencer and Jones 1991a; 1991b), as well as taking on board results from the public economics literature on passthrough in oligopolistic markets (Myles 1995).[24] At the same time, it was striking that analysis of agricultural policy reform treated the sector under study as the final goods sector, ignoring distribution and retailing networks. In this context, McCorriston and Sheldon (1996b) adapted the (Dixit 1987; 1988) model to consist of successive oligopolistic stages: a wholesaling (upstream) stage which processes/distributes an imported commodity such as bananas; and a retailing stage (downstream) which then sells the commodity which has been branded, e.g., Chiquita *vs*. Dole bananas. Like most vertical market models of that vintage, the downstream stage is linked to the upstream stage by a one-to-one fixed proportions constant cost technology, and there is arms' length pricing between wholesale and retail. [25] This of course ignores the rich set of vertical contracts discussed above, but our interest here was to evaluate how successive oligopoly could affect passthrough to final banana prices of policy changes targeted at imported bananas.

Given the linear inverse derived demand function at wholesale, and the assumptions on technology, equilibrium at the wholesaling stage is described by an equation system similar to (26), and the whole vertical system can then be calibrated as with the single-stage Dixit (1987) model. In McCorriston and Sheldon (1996b), we applied the model to the UK banana marketing system, evaluating a reduction in the effective tariff imposed on ACP banana imports. The empirical results indicated that both the number of vertical stages and the degree of imperfect competition at either stage reduced tariff passthrough compared to a competitive vertical marketing system. In other words, extant analysis of agricultural policy reform would have likely over-estimated the benefits to UK banana consumers of trade liberalization.

Following reviewer comments on McCorriston and Sheldon (1996b), the remainder of our research program in this area shifted to developing a vertical market model with more general demand, and one that did not depend on modeling oligopoly with conjectural variations. I will describe this research shortly. However, we did collaborate with Rich Sexton and Humei Wang at the University of California-Davis on a vertical NIO model that has a richer structure than the Dixit-type model (Sexton, Sheldon, McCorriston, and Wang 2007). Building on Huang and Sexton (1996), and Sexton and Zhang (2001), a vertical market model was developed where a primary agricultural commodity such as coffee is exported from a developing economy, and then processed and sold in a developed economy. Given inverse excess supply of the raw commodity, and inverse excess demand at retail for the processed commodity, the processor-retailer part of the marketing chain is modeled as imperfectly competitive, firm behavior at both stages being modeled via conjectural variations, technology at both stages being quasi-fixed proportions. Assuming general functional forms for commodity supply and retail demand, with successive

processing and retail oligopoly, and processor oligopsony power, the profit-maximizing conditions for representative retailing and processing firms respectively are:

$$p^r\left(1-\frac{\lambda^r}{\eta^r}\right)=p^w+c^r \tag{27}$$

$$p^w\left(1-\frac{\xi^w}{\eta^w}\right)=p^f\left(1+\frac{\theta^f}{\varepsilon^f}\right)+(c^w+t), \tag{28}$$

where in (27) η^r is the price elasticity of demand at retail, λ^r is the retail oligopolistic markup, p^w is the wholesale price of the processed commodity, and c^r are constant retailing costs; and in (28) η^w is the elasticity of derived demand at wholesale, ξ^w is the processor oligopolistic markup, p^f is the price of the raw agricultural commodity, θ^w is the processor oligopsonistic markdown, ε^f is the price elasticity of supply for the raw commodity, c^w are constant processing costs, and t is an import tariff imposed on the raw commodity. If aggregated over retail and processing firms, (27) and (28) would be the relevant Lerner indices of market power at retail and processing respectively, the latter also incorporating the Lerner index of oligopsony power.

Assuming linear inverse retail demand and commodity supply, we calibrated the model, and then simulated the impact of the developed economy reducing its import tariff. The empirical results indicated that relatively modest departures from imperfect competition in the marketing chain could result in processors and retailers capturing the benefits of agricultural trade liberalization, with the possibility of commodity producers in developing countries receiving a lower share of total value added. These results are driven by two key aspects of market structure: first, the processor continues to capture oligopsonistic rents when the tariff is reduced; and, second, the tariff reduction is only partially passed through to consumers under successive processor-retailer oligopoly.[26]

The possibility of less than perfect passthrough of changes in costs in the presence of imperfect competition is well understood if demand is linear, but what happens with more general demand?[27] In Sheldon, Pick, and McCorriston (2001), we assumed a vertical market structure consisting of home and foreign commodity producers, duopolistic intermediate processors and final processors, with indirect international competition between intermediate processors and direct international competition between final processors, final goods being strategic substitutes. Given this structure, an equivalent export subsidy could be targeted either at home agricultural producers or foreign final processors by their respective governments.[28] Successive duopoly was captured by linking final processing equilibrium in equation (15) to a similar equilibrium in intermediate processing via a one-to-one fixed proportions technology. The key finding was that, under certain circumstances, the export subsidy to home agricultural producers could have greater profit-shifting effects at the final processing stage than an export subsidy targeted at foreign final processing, both policies shifting profits to the foreign intermediate processing. The magnitude of these effects was shown to depend on two factors: the extent which the home export subsidy raises the price of the home agricultural commodity, and the degree of passthrough by the home intermediate processor. The latter is dependent upon the degree of convexity of the inverse derived demand function.[29]

In conducting the research in Sexton, Sheldon, McCorriston, and Wang (2007), McCorriston and I also started thinking about the issue of tariff escalation with successive oligopoly (McCorriston and Sheldon 2011). Tariff escalation occurs when tariffs on downstream imports are higher than those on upstream imports, the level of protection offered downstream being higher, where goods are typically more processed. The vertical market structure in Sheldon, Pick, and McCorriston (2001) was adapted so that a downstream processing firm competes with imports

of the final good, the upstream intermediate good being purchased from home and/or foreign sources, a tariff being applied at both the downstream and upstream stages which are both assumed to be imperfectly competitive.

The key finding in this article was that cutting tariffs at the intermediate and final good stages by an equivalent amount, will have a differential effect on market access and hence home-firm profits at each stage. This result comes about due to the interaction of both horizontal and vertical market effects, specifically the extent of passthrough of the intermediate stage tariff cut, the degree of pass-back of the final stage tariff cut, and the extent to which changes in domestic downstream output affect imports of the intermediate good. An important policy implication of this research is that formula approaches to tariff reduction in trade negotiations may be a means to preventing either tariff escalation or de-escalation.

Finally, an aspect of vertical market structures that really caught our attention in the late-1990s involved trade and the use of border tax adjustments (BTAs) in the presence of domestic environmental policy (McCorriston and Sheldon 2005a; 2005b). If environmental taxes are unilaterally imposed by a country, home firms are likely to suffer a loss of "competitiveness" if foreign competition is not subject to a similar tax. In addition, with a carbon tax, there is potential for carbon "leakage", i.e., reduced home emissions are replaced by foreign emissions. Therefore, there may be an argument for applying a BTA on imported goods to restore competitiveness.[30] This leads to two interconnected questions: at what level should a BTA be set if an environmental tax is targeted at an intermediate input, but the imported good(s) is a final good containing the intermediate input; and, how should the BTA be set so as to not violate World Trade Organization (WTO) rules on BTAs?[31]

Applying our vertical market model, we showed that in the presence of successive oligopoly, the appropriate BTA depends on the nature of competition at each stage, the extent of passthrough of the environmental tax, and how restoring home firm competitiveness is defined, i.e., pre-environmental tax market volume *vs*. market share.[32] If the former, carbon leakage can be prevented, but profits are shifted to the foreign firm, while if the latter, negative carbon leakage is possible, and profits of all firms increase. These results were later verified in a calibrated empirical analysis of US aluminum production, an industry that is very intensive in its use of a carbon-intensive input – electricity (Sheldon and McCorriston 2017). The latter analysis also highlighted an important practical policy tension between targeting an environmental market failure in the presence of a second market failure, that is exploitation of market power. It should be noted that after this article was published, we finally retired our calibrated model, as I am sure readers will be relieved to know.

In some respects, I think this has been one of my most important research contributions: evaluating policy outcomes in the presence of successive oligopoly. This obviously relates to the now extensive literature on price transmission in the food marketing system, as well as the wide-ranging literature on modeling and evaluating the extent of vertical coordination in that system.[33] However, the stripped down models of successive oligopoly McCorriston and I used clearly do not capture the complexity of vertical market relationships in the food marketing system. Although I would point out that incorporation of the interaction between market power, processing technology, and economies of scale (McCorriston, Morgan, and Rayner 1998; 2001), along with analysis of the effect of multiple products (Hamilton 2009; Richards and Hamilton 2015), has pushed analysis of price transmission forward substantively.

Finally, I would draw attention to a growing empirical literature focusing on performance of firms in global markets, with a focus on the effect on firm markups of trade liberalization in intermediate and final goods markets (De Loecker, Goldberg, Khandelwal, and Pavcnik 2016).[34] The latter analysis indicates that in evaluating downstream firm markups, there is a tradeoff between two effects: markups can rise due to less than complete passthrough of reductions in tariffs on intermediate inputs, and markups can fall because of the disciplining effect of import competition in final goods markets. With wider availability of firm-level datasets, I would encourage others to explore this interesting line of research, but at the same time pay attention to the agricultural economics literature that has also long evaluated price transmission in vertical markets.[35]

International Economist

Intra-Industry Trade

As noted earlier, McCorriston and I devoted ourselves in most of our joint research to working on imperfect competition and trade policy. However, some of our early work together drew as much on the literature explaining the phenomenon of intra-industry trade, i.e., the simultaneous export and import of products that are very close substitutes for each other in terms of factor inputs and consumption (Tharakan 1981). Initial work on intra-industry trade essentially focused on its measurement, stimulated by its discovery in trade patterns between members of the then European Economic Community (EEC) by, *inter alia*, Balassa (1965).[36] Our very first co-authored article applied the Kol and Mennes (1986) index of intra-industry trade to EC manufacturing industry data (McCorriston and Sheldon 1989a). The key departure of this index, as compared to those developed by Balassa (1965), and Grubel and Lloyd (1975), was that it allowed a test of statistical significance for changes in trade patterns over time.[37] We subsequently extended this analysis to

comparing the extent of intra-industry trade and specialization for the US and EC in processed agricultural products, our results showing that, over the period 1977-1986, the EC showed a greater tendency towards intra-industry specialization than the US (McCorriston and Sheldon 1991b).[38] According to Carter and Yilmaz (1998), this article was one of the first to examine intra-industry trade in the food and agricultural sector, and I am happy to let them be the judge of that!

Leamer (1992) argued that other than the Leontief (1953) paradox Grubel and Lloyd's (1975) work (on intra-industry trade) was the only empirical finding at the time presenting an important and substantive challenge to neoclassical trade orthodoxy. Essentially, the traditional model of comparative advantage was not thought capable of rationalizing intra-industry trade, whereas scale economies provides a motivation for specialization and hence, two-way trade in differentiated products, where the market structure is one of monopolistic competition. While other market structures can predict intra-industry trade, the incorporation of monopolistic competition into general equilibrium trade modeling marked a seminal development in international economics, especially the contributions that were eventually synthesized in Helpman and Krugman (1985).[39]

Importantly in the latter analysis, they were able to show that the share of intra-industry trade in total trade will be higher the greater the equality of countries' GDP per capita (Helpman and Krugman (1985, Ch.8., pp 169-178). As noted in subsequent empirical work by Helpman (1987), the relationship being tested fits the general form of the gravity equation. Since taking on a full-time faculty position at Ohio State in 1990, I have published at least one article every decade using some version of the gravity equation, supporting my earlier (perhaps dubious) claim to have become as much an international economist as opposed to an industrial organization economist.

The Gravity Equation

My first attempt at empirical work on the gravity equation managed to do so without ever calling it as such! In Hirschberg, Sheldon, and Dayton (1994), we tested Helpman and Krugman's (1985) hypothesis using bilateral trade in the food processing sector for a 30-country sample over the period 1964-85. In retrospect, this article is distinguished by the fact that the gravity equation we estimated actually had many of the features of modern empirical analysis in the area: we used a panel data set with country and time fixed effects, estimated using a weighted tobit model. The latter was used to deal explicitly with the Grubel and Lloyd (1975) index of intra-industry trade being zero for a proportion of the sample, indicating either one-way trade or no trade between specific country pairs. The results presented in this article showed that intra-industry trade in food processing over the sample time-period was a positive function of a country's GDP per capita, and equality of GDP per capita between countries. In addition, bilateral trade was also strongly influenced by the typical gravity variables: distance between trading partners, membership in customs unions, and exchange rate volatility.[40]

While not the central focus of the analysis in Hirschberg, Sheldon, and Dayton (1994), inclusion of exchange rates was key to the gravity model I worked on in the next decade. Specifically, in Cho, Sheldon, and McCorriston (2002), our interest was in evaluating the effects of medium/long-term changes in exchange rates on bilateral trade flows using a panel data set of ten developed countries for the period 1974 to 1995, and comparing the growth in agricultural trade with that of other sectors. The key point of this research was the argument that short-run exchange rate risk can be readily hedged at low cost, and it is long-run variability in exchange rates that is most likely to affect trade.[41] Specifically, it is "sustained" misalignment of the real exchange rate that matters, i.e., their deviation from market fundamentals such as relative prices and interest rate differentials between countries (Williamson 1985).[42] Using an index of medium

to long-run exchange rate uncertainty due to Perée and Steinherr (1989), we estimated a typical empirical gravity equation using panel fixed effects, the results indicating that real exchange rate uncertainty had a significant negative effect on agricultural trade over the sample period, agricultural trade being more affected by such uncertainty compared to other sectors.

Two comments on Cho, Sheldon, and McCorriston (2002) are in order. First, despite the fact that it is very clear in this article that we were focusing on long-run exchange rate misalignment, virtually all of the agricultural economic research on exchange rates since, with the exception of Kandilov (2008), has used high frequency data focusing on short-run exchange rate volatility. Therefore, I would make a pitch for other researchers to take another look at this issue, especially in the context of the Euro-zone crisis. Second, this article used what were then considered to be best-practice econometric techniques in gravity equation estimation, i.e., use of country fixed effects to account for omitted variables specific to each country. Of course, it was not until Anderson and Wincoop (2003) that a proper theoretical foundation was presented for this type of empirical gravity equation, country fixed effects capturing what they termed as "multilateral" trade resistance terms.

The latter point is important with respect to my subsequent contribution(s) applying the gravity equation to food and agricultural trade. As pointed out by Evenett and Keller (2002), there was a model identification problem with the empirical gravity equation pioneered by Tinbergen (1962): it worked well for both differentiated and homogeneous goods. In fact, at that point the gravity equation could be derived from quite different theoretical models: an Armington demand structure (Anderson 1979; Bergstrand 1985); increasing returns (Helpman 1987; Bergstrand 1989); technological and geographical differences (Davis 1995; Eaton and Kortum 2002; Melitz 2003); and factor endowment differences (Deardorff 1998; Evenett and Keller 2002).

In reviewing this literature for a paper I presented at meetings of the International Agricultural Trade Research Consortium (IATRC) in 2005 (Sheldon 2006), I focused the bulk of my remarks on one specific strand in the literature developing a broader gravity equation framework allowing for both perfect and imperfect specialization in trade (Evenett and Keller 2002). My cardinal sin in this review was to ignore articles by Eaton and Kortum (2002), and Melitz (2003) that have proven key contributions to development of a new applied general equilibrium framework in international economics (Costinot and Rodríguez-Clare 2014), and the more recent empirical literature on the gravity model (Head and Mayer, 2014).[43]

The central focus of Eaton and Kortum (2002) and Melitz (2003) was to (re)-introduce productivity into trade models at the country- and firm-levels.[44] Eaton and Kortum (2002) extended the Ricardian model beyond the two-country continuum of goods model of Dornbusch, Fischer, and Samuelson (1977), while Melitz (2003) incorporated firm heterogeneity into a monopolistic competition setting. [45] Importantly, empirical gravity equations can be derived from both of these theoretical frameworks, from which the elasticity of trade with respect to trade costs can be calculated (Arkolakis, Costinot, and Rodríguez-Clare 2012).[46]

In fact, the gravity equation is general enough that it can be shown to hold under other market structures, including Bertrand competition (Bernard, Eaton, Jensen, and Kortum 2003); and, monopolistic competition with homogeneous firms (Krugman, 1980). Following (Costinot and Rodríguez-Clare 2014), the generality of gravity can be captured in the following equation describing the conditions under which there are no arbitrage opportunities through trade:

$$P_{ij} = \tau_{ij} c_i^p \times \left(\left(\frac{E_j}{c_{ij}^x} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ij} c_i^p}{P_j} \right)^{\eta} \times \left(\frac{R_i}{c_i^e} \right)^{\frac{\delta}{1-\sigma}}, \tag{29}$$

where P_{ij} is the aggregate price of goods from country *i* in country *j*. Focusing on the first term on the right-hand side, $\tau_{ij}c_i^p$, captures the intensive margin of trade, where $\tau_{ij} \geq 1$ are iceberg transport costs, and c_i^p indexes how input prices affect variable costs of production. This captures changes in the prices of goods from country *i* imported by country *j*, and it operates whatever is assumed about market structure. For example, if labor is the only factor of production, variable costs will be proportional to wages in country *i*, and the extent of trade costs between country *i* and *j*.

The second term, $\left(\left(\frac{E_j}{c_{ij}^x} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ij}c_i^p}{P_j} \right)^{\eta}$, captures changes in the extensive margin due to selection, where E_j is total expenditure in country *j*, c_{ij}^x are fixed exporting costs, δ is a parameter capturing market structure, equal to zero under either perfect or Bertrand competition, and equal to one with monopolistic competition, $\eta \geq 0$ indexes heterogeneity of firms exporting to *j*, and σ is the elasticity of substitution between varieties of goods along a continuum. This is best understood in the context of the Melitz (2003) model, capturing the sub-set of firms in country *i* that select into exporting to country *j*. In this case $\eta > 0$ and $\delta = 1$, generating two separate effects: first, the number of firms that select into exporting is contingent on their draw from a productivity distribution (Pareto) in conjunction with their variable costs of production; and, second, selection into exporting depends on the size of the export market relative to the fixed costs of exporting.[47]

The third term, $\left(\frac{R_i}{c_i^e} \right)^{\frac{\delta}{1-\sigma}}$, captures changes at the extensive margin due to entry effects, where R_i is total revenue of producers, and c_i^e are fixed entry costs into the industry. Again, if $\eta > 0$ and $\delta = 1$, this captures both the Krugman (1980) and Melitz (2003) monopolistic competition models with fixed entry costs, the number of firms that enter depending only on profitability.

My recent empirical work in collaboration with graduate students, has focused on estimating structural gravity equations. In Eum, Sheldon, and Thompson (2017), we used a neo-Ricardian setting similar to Reimer and Li (2010) to evaluate the extent to which bilateral agricultural trade between developed and developing countries is characterized by asymmetric trading costs as well as differences in productivity.[48] Without working through the derivations, a model of this type yields a structural gravity equation:

$$\ln(X_{ij} / X_{jj}) = S_j - S_n - \theta\tau_{ij}, \tag{30}$$

where the dependent variable is expenditure on imports by country *j* from country *i*, relative to expenditure on goods produced in country *j*, S_j and S_i capture the relative "competitiveness" of countries *j* and *i*, defined as the combination of average productivity, T_i, and the land rental rate r_i, i.e., $S_i \equiv \ln(T_i r_i^{\theta})$, given productivity z_i in country *i* is drawn from a Fréchet distribution $F_i(z) = \exp\left\{-T_i z_i^{-\theta}\right\}$, where $\theta > 1$, which is common across countries, governs the dispersion of productivity, and is interpreted as the elasticity of trade. In addition, trade costs, defined as $\ln \tau_{ij} = b_{ij} + l_{ij} + RTA_{ij} + d_{ij} + ex_j + v_{ij}$, consist of a set of variables typical to empirical gravity equations: common border, b_{ij}, common language, l_{ij}, membership of a common regional trade agreement, RTA_{ij}, distance, d_{ij}, and exporter fixed effects, ex_j. Following a strategy suggested by Waugh (2010), we estimated (30) using agricultural trade for a sample of 128 countries in 2013, our estimated elasticity of trade being relatively lower than estimates for the manufacturing sector, implying comparative advantage can offset trade costs in the agricultural sector, the latter being higher for developing countries.[49]

In Eum, Sheldon, and Thompson (forthcoming) we estimated a structural gravity equation drawing on Melitz (2003), using methodology developed by Helpman, Melitz, and Rubinstein

(2008). The latter suggest an approach whereby zeros in bilateral trade data can be used to make inferences about the extensive margin of trade due to firm selection, i.e., if there is no trade between countries, it is because no firm(s) has sufficiently high productivity to export.[50] Helpman, Melitz, and Rubinstein (2008) extend the Heckman (1979) selection model where in the first stage, a Probit model is used to estimate a selection equation, the results of which are then used to estimate a standard gravity equation where selection bias is controlled for, the second stage accounting for the intensive margin of trade.[51] Our twist on this is to evaluate the connection between firm-level productivity and product quality – termed "firm capability", an idea due to Sutton (2007). Using a bilateral food and agricultural trade dataset for 159 countries over the period 2010-13, we found a high firm capability cutoff limits export market entry. In addition, trade at the extensive margin was found to be negatively affected by both fixed and variable trade costs, while trade at the intensive margin was affected negatively by variable trade costs.[52]

As well as constituting a means of estimating the extensive margin of trade due to firm selection, the econometric methodology proposed by Helpman, Melitz, and Rubinstein (2008) is a way of handling zeros in bilateral trade data, an issue that often confronts gravity equation estimation. However, Santos Silva and Tenreyro (2015) have raised some doubts about the statistical validity of the methodology, proposing as an alternative, a Poisson Pseudo-Maximum Likelihood (PPML) method (Santos Silva and Tenreyro 2006), which is now widely used in the empirical literature, e.g., Anderson and Yotov (2010).[53] Specifically, this methodology utilizes the information contained in the zero trade flows, as well as controlling for heteroskedasticity.

Zhou, Sheldon, and Eum (2018) used the PPML methodology to evaluate the effect of intellectual property rights (IPRs) on US seed exports for a panel of 134 countries over the period 1985-2010. The empirical results indicate that IPR protection such as that offered through the

International Union for the Protection of New Varieties of Plants (UPOV), and the Trade-Related Aspects of Intellectual Property Rights Agreement (TRIPs) of the WTO, have had a positive effect on US exports of field crop seeds. Interestingly, in also applying a Heckman (1979) selection model, these results proved to be robust to estimation method.[54]

Although I started out estimating a gravity equation that drew on Helpman and Krugman's (1985) monopolistic competition model of intra-industry trade, many of my subsequent contributions are legitimately open to the criticism that they were based on an *ad hoc* empirical model. It is only recently that, in collaboration with graduate students, I have been able to apply structural gravity models using current econometric methods. This of course reflects the huge progress made in the international economics literature towards showing how general gravity is, the model incorporating a wide range of market structures – something that I truly appreciate, having started out as an industrial organization economist interested in trade. In addition, better data and econometric methods have made gravity equation estimation commonplace in the empirical trade policy literature. My work in this area has resulted in my often being asked to review manuscripts using some form of a gravity equation. This leads me to some, hopefully, "sage" advice to prospective authors: know the history of the model and its weaknesses, and make sure you properly understand the advances in both theory and econometric methodology, i.e., gravity matters, but one more rote application is probably not going to be that interesting to either a reviewer or reader(s).

Summary and Conclusions

In this article I was lucky enough to be allowed the self-indulgence of reflecting on my career as an industrial organization and international economist. If I had to pinpoint a broad contribution, it would be the careful synthesis of market structure and firm behavior in models of food and

agricultural trade, and how that affects policy outcomes. More specifically, McCorriston and I were partially if not most responsible for incorporating ideas from strategic trade theory into the analysis of agricultural trade economists, and then extending those ideas to vertical market structures. Also, while using it at various stages of my career in the US, development of the gravity equation to be consistent with a range of market structures, has not only allowed me to conduct more meaningful empirical work, but it has brought me back full circle to my starting point: the impact of market structure on international trade.

In terms of future work in this area, I would strongly encourage agricultural and industrial organization economists who have pioneered rigorous analysis of contractual relationships in the agricultural and food marketing system, to push agricultural trade economists to pay closer attention to the intricacies of vertical market structures, as well as tying this to thinking about global value chains and trade in intermediate goods. In addition, with more firm-level datasets becoming available, I think there is great potential for empirical analysis of how trade policy affects productivity and hence markups of final food processing and retailing firms. Finally: if you want to apply the gravity equation to food and agricultural trade, be sure to make a discrete contribution either to theory and/or to econometric methodology, because it is already a very crowded "dance-floor".

As for my own current research, one strand comes from getting to know Professor Daniel Chow, a law professor at Ohio State, with whom I collaborate on articles for international trade law journals, e.g., Chow and Sheldon (2019). In another strand, I am combining my long-standing interests in food safety and credence goods with that in vertical market structures to think about an issue that is exercising many of my former countryfolk: the potential for reduction in its food standards now that the UK has actually left the EU. In this respect, I think I have come up with

my favorite paper title so far: “Brexit: Why did the ‘chlorinated chicken’ cross the pond?” (Sheldon 2019b). At this juncture, I will finish with the immortal lyrics of the Grateful Dead,

“…Lately it occurs to me, what a long strange trip it’s been…”
(*Truckin’* by Garcia, Lesh, Weir, and Robert Hunter, *American Beauty,* 1970)

Notes

[1] While Jacquemin (1987) is credited with coining the term the "new industrial organization", Bresnahan (1989) seems to have come up with the "new empirical industrial organization", having described it as an "empirical renaissance" in an earlier article (Bresnahan and Schmalensee 1987).

[2] See Weiss (1971) for an extensive survey of empirical SCP research. Connor, Rogers, Marion, and Mueller (1985) summarize the results for the US food manufacturing industry.

[3] See Schmalensee (1989) for the most thorough critique of this literature.

[4] See also Clarke and Davis (1982) for the closed economy version of this argument.

[5] The contributions of Dixit (1984; 1988), who was also a professor of economics at the University of Warwick in the 1970s, were especially important in this respect.

[6] See Feenstra (1995) for an extensive survey of this literature.

[7] The first substantive published research on the UK food manufacturing industry was a text edited by Burns, McInerney, and Swinbank (1983).

[8] See Brander (1995) for a thorough survey of this literature.

[9] I would also add Dixit (1984; 1986; 1988) as articles that strongly influenced our research as it proceeded.

[10] The Brander and Spencer (1985) result is subject to multiple caveats, including, *inter alia*, it ignores general equilibrium effects (Dixit and Grossman 1986), and the choice of an export subsidy is sensitive to the duopoly market structure (Dixit 1984).

[11] See Reimer and Stiegert (2006) for a review of strategic trade theory and applications to food and agricultural markets.

[12] Our first published article relating to the fertilizer industry actually had nothing to do with imperfect competition, instead it focused on evaluating the effect of the UK's accession to the

European Community on the agrochemical, fertilizer, and tractor industries (McCorriston and Sheldon 1989b).

[13] I presented an early version of this article at the 1988 AAEA meetings in Knoxville, Tennessee, going on to become a visiting professor at Ohio State in 1989, associated with the North Central Regional Research Project, "Organization and Performance of World Food Systems: NC-194", and working with another mentor Dennis Henderson. Subsequently, I was hired as an associate professor at Ohio State in 1990. I believe I have Jim MacDonald to thank for turning this position down before I was eventually offered it!!

[14] See McCorriston and Sheldon (1996a) for further discussion of issues concerning the use of conjectural variations in applied industrial organization research.

[15] See Sheldon (1992) for a discussion of how to calibrate this model, a methodology described by Krugman (1986) as "Industrial Policy Exercises Calibrated to Actual Cases" (IPECACS). Thursby and Thursby (1990) is another example of an IPECAC in agricultural economics.

[16] This follows the tradition in the international economics literature regarding the equivalence of tariffs and quotas from Shibata (1968) onwards.

[17] The first article we published using the calibration model examined the impact of proposed nitrogen limitation policies on the UK fertilizer industry (McCorriston and Sheldon 1989b). In a companion piece to McCorriston and Sheldon (1993), we also compared the welfare effects of an optimal tariff on fertilizer imports with an optimal "anti-trust" production subsidy (McCorriston and Sheldon 1991a). An innovation of the latter article was to show how optimal policies should be adapted in the face of structural change in the industry.

[18] In passing, I should note that I presented a working paper version of this article at a conference held at the Institut d'Economie Industrielle, in Toulouse, France in October 1993. What I

remember most, other than the great conference food, was that speaking in front of Jean Tirole was a great honor for me personally, albeit rather nerve-wracking!!

[19] The economics of auctioning US cheese import quotas was also analyzed using this calibrated model, the results indicating that while selling quota licenses could have raised Treasury receipts, it could have generated a net welfare loss (McCorriston and Sheldon 1994b).

[20] This research was based on using both static and dynamic NEIO models. I ended up publishing two more NEIO-type articles, Deodhar and Sheldon (1997), and Katchova, Sheldon, and Miranda (2005). For critical surveys of the NEIO literature relating to the food and related industries, see: Sexton and Lavoie (2001), Sheldon and Sperling (2003), Perloff, Karp, and Golan (2007), and Sheldon (2017).

[21] The final part of this research agenda examined the non-equivalence of tariffs and quotas, as well as voluntary export restraints (VERs), and evaluated their effects with Dixit's (1987) data for the US automobile industry (McCorriston and Sheldon 1997a). I would note that I did contribute to an article on tariff-rate quotas (TRQs), but the focus was not on imperfect competition (Boughner, de Gorter, and Sheldon (2000).

[22] For example, see Waterson (1982), Abiru (1988), and Salinger (1988) for typical articles on this issue.

[23] See the relevant sections of Marion (1986) for early discussion of vertical coordination in the US food system.

[24] Other than writing a literature review (Sheldon 2017) and book chapter (Sheldon 2019a) on vertical markets and the food marketing system, I have made only one modest contribution relating to contracting and imperfect information (Sheldon 1996), and another describing US and UK competition policy towards vertical restraints (McCorriston and Sheldon 1997b).

[25] For example, see Salinger (1988), and Spencer and Jones (1991a)

[26] We did not try to model bilateral bargaining power between processors and retailers in this framework as it would have required a bargaining framework.

[27] See Feenstra (1995) for a discussion of passthrough of a tariff when the foreign supplier is a monopolist facing a linear import demand curve. Faced with a tariff, the monopolist raises price by only half as much as the increase in their marginal costs, which is terms of trade gain for the importing country. This follows from the fact that the monopolist's marginal revenue curve slopes at twice the rate of its demand curve. If the foreign supplier(s) are oligopolists, their perceived marginal revenue curve rotates up towards their demand curve, increasing the rate of passthrough of the tariff.

[28] This was designed to capture the difference between the EC and US export subsidy policies, the former targeting the final good, the latter the agricultural commodity.

[29] The degree of under/over-shifting is determined by the elasticity of the slope of the inverse derived demand function, known as Seade's *E* (Myles 1995).

[30] In the case of the export of final goods, we evaluated a refund at the border of the home environmental tax to restore competitiveness in the international market (McCorriston and Sheldon 2005b).

[31] In principle, BTAs do not contravene WTO rules, GATT Articles III and XVI allowing countries to adjust excise taxes on imported goods up to the same level as those on domestic goods, i.e., BTAs should not be discriminatory. These rules also extend to BTAs applied to imported derivative goods where the excise tax is imposed on the intermediate good. However, the debate over the legal permissibility of BTAs for environmental taxes has not been settled – see Sheldon (2010; 2011; 2018).

[32] The WTO rules on BTAs are based upon the principle of "preserving competitive equality in trade" (Demaret and Stewardson 1994), but the latter is not specified precisely. In our analysis, we defined an appropriate BTA as one ensuring that either the volume or market share of imported goods is restored to the pre-environmental tax level.

[33] See Lloyd, McCorriston, and Morgan (2015) for a detailed discussion of this issue in the EU.

[34] In an excellent survey of this literature, De Loecker and Goldberg (2014) provide a very clear connection between the measurement of firm-level productivity and firm-level markups.

[35] As noted earlier, the trade literature has typically pointed to exchange rate passthrough.

[36] The extant empirical literature was surveyed by Greenaway and Milner (1986).

[37] See Sheldon (2006) for a discussion of the various indices of intra-industry trade.

[38] This research was initially presented at the AAEA meetings in Baton Rouge, LA, and was the first time I interacted with Emilio Pagoulatos who published an early article on intra-industry trade (Pagoulatos and Sorenson 1975). These meetings were also memorable for the impact of hurricane Chantal that came through at the same time!

[39] I was particularly intrigued by Shaked and Sutton's (1984) natural oligopoly/vertical product differentiation model of intra-industry trade, but it was only until I collaborated with my Ohio State colleague Brian Roe, that I really came to grips with that approach when applying it to credence goods (Roe and Sheldon 2007).

[40] I co-authored a second article on intra-industry trade and a gravity-like equation in the 1990s, covering a cross-section of 37 industries in the US food processing sector (Hartman, Henderson, and Sheldon 1993). In many ways, this had more of a flavor of an SCP study, and, unlike Hirschberg, Sheldon, and Dayton (1994) it was not rooted explicitly in any underlying theory of gravity.

[41] See De Grauwe and de Bellefroid (1987) for the original argument.

[42] See Sheldon, Mishra, Pick, and Thompson (2013) for a discussion of the literature on exchange rates.

[43] See also Anderson's (2011) extensive review of the gravity model.

[44] See Eaton and Kortum (2012), and Melitz and Redding (2014) for excellent reviews of these developments.

[45] In McCorriston and Sheldon (1994c) we applied the Dornbusch, Fischer, and Samuleson (1977) model to thinking about US competitiveness. In addition, in Sheldon (2012) I adapted the Copeland and Taylor (1994) trade and environment version of this model to examine the impact of standards.

[46] See also Devadoss and Luckstead (2019) for a survey of this literature.

[47] In Eaton and Kortum's (2002) setting, the extensive margin will be a function of which country is the most productive, and, therefore, able to offer the lowest price for a specific good.

[48] This article was included in a special issue of the *Journal of Agricultural and Food Industrial Organization* honoring the many research contributions of Emilio Pagoulatos.

[49] In current work with Kari Heerman that draws on Heerman (forthcoming), we show that if systematic heterogeneity of agricultural productivity across countries and products is also accounted for in the gravity equation, the elasticity of trade varies significantly across countries (Heerman and Sheldon 2018)

[50] In a more direct test of Melitz's (2003) hypothesis concerning heterogeneity of firms Hasan and Sheldon (2016) used a Latin-American dataset to evaluate the impact of credit constraints on firms' ability to export.

[51] See Chaney (2008) for a theoretical development of this argument.

[52] To satisfy the exclusion restriction in this model, fixed trade costs were included in the first stage but not the second stage of estimation.

[53] Recent work by Martin and Pham (2019) and Martin (2020) has raised what appear to be some important statistical concerns about the PPML methodology.

[54] In this application, the focus is on US seed exports only, the extensive margin of trade being a function of which markets firms enter, as opposed to which firms enter which markets.

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