International Food and Agribusiness Management Review

Official Journal of the International Food and Agribusiness Management Association

Volume 17: Issue 2
2014

International Food and Agribusiness Management Review

Editorial Staff

The IFAMR (ISSN #: 1559-2448) is published quarterly and is available at http://www.ifama.org. For copyright and publishing information, please contact: Kathryn White, Administrative Editor. IFAMA Business Office • 1511 15th Street, NW Suite 500 Washington, DC 20005 • USA • Tel: 1 (202) 429-1610 • Fax: 1 (202) 530-0659 • E-mail: ifamr@ifama.org • Web: http://www.ifama.org

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EDITOR'S NOTE

Dear Readers,

The IFAMR editorial team and reviewers have been hard at work providing food and agribusiness management scholars the impact they deserve. This is our second quarterly issue, and the third issue we've published in 2014. A second Special Issue will be published later this month on African entrepreneurship. Thus, the IFAMR in the first half of 2014 will publish 50 articles and is on pace to have 165,000 articles downloaded.

This issue, *Volume 17 Issue 2*, reflects the increasing recognition the IFAMR is receiving as a high quality journal outlet for Brazilian scholars. Please take a moment to review the three Brazilian articles discussing the raw milk, sugarcane, and beef industry chains. As many of our colleagues know, publishing in a second language is difficult. These scholars work hard to translate their research accurately and often incur the added expense of retaining a specialized English technical editor. The journal editors and reviewers appreciate the extra effort authors make to ensure their manuscripts are grammatically correct and free of errors prior to submitting their research to the IFAMR for peer review.

Finally, please note the Executive Interview with Eric Raby of AGCO, written by Kateryna (Goychuk) Schroeder, now a post-doctoral fellow at the University of Missouri. Mr. Raby discusses AGCO's international strategy, which is of particular interest because of our upcoming IFAMA - CCA World Forum in Cape Town. AGCO recently opened a research farm in Zambia. The IFAMR always welcomes Executive Interviews, whether conducted by professional communication specialists, faculty, or students.

Enjoy the issue.

Peter Goldsmith, Executive Editor, IFAMR

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Measuring the Degree of Oligopsony Power in the Brazilian Raw Milk Market

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Abstract

This study sets out to measure the degree of oligopsony power in the Brazilian raw milk market. The analysis was undertaken in fifteen producing regions between January 1997 and December 2011. The results led to the authors rejecting the monopsony hypothesis. In six regions, the hypothesis of perfect competition was not rejected. In the other nine, the conduct parameter estimates were very close to zero. These results contradict both the empirical literature and the reports produced by Parliamentary Inquiries in the early 2000s, which found suspicions of market power in dairies in several Brazilian states. Although the dairy industry concentrates on the marketing of Brazilian raw milk, the survey results indicate that the behavior of firms is similar to that of a perfect competition market model.

Keywords: oligopsony power, dairy sector, imperfect markets, market concentration, new empirical industrial organization.

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Introduction

In Brazil, the first half of the 1990s saw the beginning of restructuring in the milk production chain. During this period, the retail prices paid for pasteurized and raw milk from farmers were no longer controlled. Furthermore, there was a trend toward the liberalization of trade and economic stabilization which led to a macroeconomic environment which helped to surmount the lack of productive dynamism seen in the sector (Martins and Faria 2006).

The liberalization of trade and differences in raw milk prices impacted the market first by increasing competition and reducing costs and inefficiency; this, in turn, increased competition and promoted quality improvement and product diversification. In the industrial sector, economic openness led to increased competition, initially via imports and, subsequently, through the entry of new multinational firms. In the distribution system, large supermarket chains became the main channel for the sale of dairy products.

Against this background, there was a wave of mergers and acquisitions (M & A), which resulted in increased industrial concentration. This first move was made primarily through the entrance of multinational companies, including Nestlé, Parmalat, Fleischmann-Royal and Danone. National companies with less financial capacity achieved a prominent role only by the mid-2000s with the second wave of mergers. National companies, including Perdigão and the Bom Gosto Dairy[1], led the M & A process. In 2007, two investment funds in the sector, Laep and GP investments gained prominence with their purchase of Parmalat in Brazil and Morrinhos Dairy, respectively.

When the raw milk market itself is analyzed, the increase in market concentration is significant because the geographical scope of the relevant market for agricultural commodities tends to be narrower than that for final products, and consequently, rural producers are restricted to few buyers, in the vicinity of their farms. In addition, the supply of raw milk is usually inelastic and there are also barriers to output. These characteristics are structural conditions conducive to the exercise of market power by the dairies (Sexton and Zhang 2001).

This issue gained prominence in the early 2000s, when Parliamentary Inquiries (PI)[2] were set up in six major milk producing states of Brazil[3] to investigate the suspected misuse of market power, price control, cartel formation (both for dairies and retailers) and the adulteration of products. All the investigations indicated that the farmers were the most vulnerable part of the

[1] Perdigão was one of the main companies in the food sector in Brazil, working primarily in the processing of chicken and pork. In 2006, it entered the dairy sector through the purchase of Batavo. Other acquisitions followed in 2007. Thus, Perdigão became the second largest milk collection company in Brazil. In 2009, it merged with Sadia, another Brazilian company in the food sector. This resulted in the creation of Brazil Foods S/A, the largest company in the food sector in Brazil. Between 2007 and 2010, the Bom Gosto Dairy acquired seven dairies scattered over Brazil's major producing states. In 2009, it became the second largest dairy in terms of quantity of milk collected. In 2010, Bom Gosto merged with the LeiteBom Dairy, giving rise to the LBR – Lácteos Brasil S/A, and in 2010 it was processing approximately 1.8 billion liters of milk per year.

[2] The PIs were committees made up of state legislators, members of the Legislative Assemblies of their respective states, with the aim of investigating the suspected manipulation of milk prices.

[3] The six states investigated were Rio Grande do Sul, Paraná, Santa Catarina, Minas Gerais, Goiás and Mato Grosso do Sul. Together, these six states were responsible for nearly 70% of the total raw milk production in 2002.

production chain and that there were high levels of market concentration, both in the dairy and retail sector. In addition, there was evidence that the dairies and large supermarket chains were able to dictate the prices paid for their inputs (ALRS 2002; ALMG 2002). Reports of these investigations were sent to the Council for Economic Defense (CADE) and whenever there are large price shocks, this same discussion arises.

This problem is also discussed in the empirical literature and concerns about increasing concentration and increasing market power are found in several studies, such as: Jank, Farina and Galan (1999), Barros, et al. (2004), Farina, Nunes and Monteiro (2005), Concha-Amim and Aguiar (2006), Martins and Faria (2006), and Azevedo and Politi (2008).

Against that background, this study hopes to contribute to the discussion on the existence of market power and fill an existing gap, specifically in the raw milk market. Its aim was to measure the degree of oligopsony power of the dairy industry over milk producers and check out if dairies really do distort the price paid for raw milk.

It is worth noting that evidence found in the Parliamentary Inquiries and certain empirical studies (Jank, Farina and Galan 1999 and Martins and Faria 2006, for example), are based on the assumption of the structure-conduct-performance paradigm which associates the increase in market concentration with the increase and, consequently, exercise of market power. This is not necessarily true (Sexton 2000). In addition, the literature does not have any study on measuring the degree of oligopsony power of the dairy industry over milk producers in the Brazilian market.

This measurement will be done from the perspective of the Theory of New Empirical Industrial Organization (NEIO), which supports the investigation of the conduct of market players and identification of the degree of market power in the industry by means of conduct parameter estimation. This parameter is a quantitative indicator which supports the inference of the degree of market distortion caused by the exercise of oligopsony power.

Similar research studies were conducted in Ukraine and Hungary. Perekhozhuk, Grins and Glauben (2009) investigated the existence of oligopsony power in 23 regions of Ukraine but only found evidence in four. However, the estimates of conduct parameters proved small (between 0.007 and 0.022). Hockmann and Võneki (2007) considered that the raw milk market in Hungary was national and rejected the hypothesis of perfect competition. However, the conduct parameter estimate was close to zero (0.001) as in the former study, which indicates that the influence of oligopsony power on the raw milk market segment was very small.

In this study, we defined the relevant geographic market for raw milk as regional and measured the degree of market power in a sample of fifteen producing regions. The monopsony hypothesis was rejected for all markets while that of perfect competition was only rejected for a few, but the conduct parameter estimates were small indicating a slight degree of oligopsony power. These results support the inference that even if the dairy industry is concentrated, it does not exercise market power, at least in relation to distortions in the prices of raw milk paid to milk producers.

The remainder of this article is organized as follows. The next section contains a description of the transformations which occurred in the Brazilian raw milk market and its main characteristics. The theoretical and empirical models of oligopsony are presented in Sections 3 and 4, respectively, while Section 5 describes the variables used in the study. The estimated results are presented in Section 6; and the conclusions in Section 7.

The Brazilian Raw Milk Market

In 1991, after 45 years of control and regulation, the government failed to set prices and allowed free negotiation between raw milk suppliers and the industry. The process of trade openness begun in 1990, and the economic stabilization achieved with the launching of the 1994 *Plano Real*, resulted in establishing the macroeconomic environment necessary for the agents in this sector to surmount the low productive dynamism of the period (Martins and Faria 2006).

This was accompanied by a significant increase in milk production, which soared from 14.4 billion liters in 1990 to 30.7 billion liters in 2010 (113% increase). Productivity also increased by 80%, according to data from the Municipal Livestock Research (PPM), conducted by the Brazilian Institute of Geography and Statistics (IBGE). However, there was a reduction in the number of farmers and an increase in production concentration. The results of the agricultural census showed a drop in the number of establishments from 1.8 million in 1985 to 1.3 million in 2006. In other words, over two decades, approximately 500,000 agricultural establishments (27%) stopped producing milk (IBGE).

The emergence of bulk milk collection and the cooling of milk on the farm required investments in specific assets, including mechanical milking systems and cooling tanks. The difficulties involved in making these investments are cited as one of the causes for the reduced number of farmers (especially small farmers). However, the drop in the prices paid for raw milk is another likely factor. Unlike the growth in production, prices continued to follow a decreasing trend and fell approximately 3% per year, from 1980 to 1994 (when the new economic plan was implemented). From August/1994 to February/1998 alone, there was a cumulative decline of approximately 40%.

The ongoing increase in raw milk production and falling raw milk prices can be explained, at least in part, by increased productivity and economies of scale and/or scope for those farmers who remained on in the sector. According to the results of the agricultural census, average production increased from 2.63 liters/cow/day in 1985 to 4.37 liters/cow/day in 2006 (66% increase) and the average volume of raw milk produced per establishment increased from 18.84 liters/producer/day to 40.93 liters/producer/day - a growth of 117% (IBGE).

In the industrial and marketing sectors, there was a wave of M & A which resulted in increased industrial concentration and increased market power of dairies and supermarkets (Jank, Farina and Galan 1999; Farina, Nunes and Monteiro 2005). Restructuring forced the farmers to negotiate with an increasingly concentrated industry (Martins and Faria 2006).

From 1990 to 2010, over fifty M & A operations were identified in the dairy industry. Between 2003 and 2010 alone the number of dairies decreased from 1,973 to 1,149 (42% reduction) in

Brazil (Conejero, Consoli and Neves 2006; Ministry of Agriculture, Livestock and Supply). At the same time, raw milk collection almost doubled between 1998 and 2010, increasing from 10.7 billion to 20.9 billion liters (Quarterly Milk Survey - IBGE). This represented 68% of all raw milk produced in Brazil in 2010, compared to 57% in 1998. Raw milk collection in the twelve major dairies also doubled over this period, but the concentration indices of these twelve and of the four largest dairies are reasonably low: 26.2% and 18.9%, respectively (Leite Brasil 2011).

It must be stressed, however, that this evidence should be carefully interpreted because the calculated concentration indices only show the concentration rate at national level. Raw milk is a perishable product and, due to transportation limitations, has numerous geographic market areas that are smaller than the nation as a whole[4]. Therefore, there could be significant regional variations. In the state of Rio Grande do Sul, for example, the PI report indicated that two companies alone (Parmalat and Elegê), accounted for approximately 70% of the raw milk market (ALRS 2002).

Finally, as regards the marketing of dairy products, after market deregulation and the promotion of trade openness, there was a significant increase in imports, which almost quadrupled between 1990 and 1995 (Ministry of Development, Industry and Foreign Trade), representing approximately 16% of national production (Barros et al. 2004). But from that period onwards, imports decreased, primarily because of currency devaluation and other protectionist measures (Barros, et al. 2004; Martins and Faria 2006). However, it is important to note that international trade plays a significant role in determining the behavior of the dairy industry through market contestability. The PI investigations indicated that imports were crucial for maintaining domestic prices (ALRS 2002 and ALMG 2002). Furthermore, Barros et al. (2004) found evidence that in the fluid milk market, domestic and foreign markets are integrated and imports are brought in with sufficient frequency to meet the needs of the domestic market, thus guiding the process of price formation. Santos and Barros (2006) also concluded that import prices provide a ceiling for the domestic market and export prices provide a floor.

Theoretical Model of Oligopsony

The model used to measure the degree of oligopsony power in the raw milk market follows the original proposal of Muth and Wohlgenant (1999), which circumvents the existing problem of the need for data, especially of non-specific inputs in the manufacturing process. The works of Hockmann and Võneki (2007) and Perekhozhuk, Grins and Glauben (2009) are other examples of the application of this model to the dairy sector.

Consider an oligopsonistic industry that demands a specific input produced by farmers, represented by a supply function in its reverse form as follows:

$$(1)\quad w_M = g(x_1, z)$$

[4] Some studies in the empirical literature defined the raw milk market as regional. See Perekhozhuk, Grins and Glauben (2009) and Alvarez et al. (2000).

where w_M is the deflated price paid to farmers for raw milk; x_1 is the amount of raw milk offered and z is a vector of exogenous factors which shift the supply. The profit equation for a representative dairy is described as follows:

$$(2)\quad \Pi = p \cdot f(x_1, x) - w_M x_1 - w' x\,,$$

where p is the deflated price for the dairy products (at the wholesale level), $f(\cdot)$ is the production function, x is a vector quantity of other inputs used in the production process (e.g., labor, energy and capital) and w is a vector of the deflated prices for the other inputs.

Assuming that dairies maximize profit and determine the price of raw milk, the demand for the specific input will be given by the first-order condition (FOC) of the profit equation (2), where the marginal cost of the input equals the marginal revenue product.

$$(3)\quad w_M\left(1+\frac{\theta}{\varepsilon}\right) = p\,\frac{\partial f(x_1, x)}{\partial x_1}\,.$$

$\varepsilon = (\partial x_1/\partial g(\cdot))(w_M/x_1)$ is the price elasticity of the supply of raw milk, and θ is a parameter which indexes the degree of market power. If $\theta = 0$, the market is perfectly competitive and the marginal revenue from the dairy product is equal to the price of the raw milk; if $\theta = 1$, the market is a monopsony, and marginal revenue from the dairy product equals the marginal input cost (price of raw milk plus a discount factor referring to the reduced monopsony price). The intermediate values of θ represent the degrees lower than full market power (monopsony), such as the condition of the Cournot equilibrium, $\theta = 1/n$. The FOC can be interpreted as the "perceived" marginal input cost for the dairy, which is equal to the marginal revenue from the dairy product.

To estimate the degree of oligopsony power, the FOC (3) must be specified with the quantity data for all non-specific inputs included in the production function $f(\cdot)$, i.e., other inputs besides x_1. As data on these questions are not available for the dairy industry, the profit equation must be redefined in order to circumvent this restriction. Muth and Wohlgenant (1999) suggest replacing the optimum amounts of non-specific inputs with their conditional quantities at the optimum level of the x_1 input. Thus, assuming that there are three non-specific inputs involved in the manufacturing of dairy produce, namely, work (x_2), energy (x_3) and capital (x_4), the profit equation (2) can be rewritten as follows:

$$(4)\quad \begin{aligned}\Pi(p, x_1, z, w_2, w_3, w_4) = p \cdot f(x_1, x_2^*, x_3^*, x_4^*) - g(x_1, z)x_1 \\ - w_2 x_2^* - w_3 x_3^* - w_4 x_4^*\end{aligned}\,,$$

where x_2^*, x_3^* and x_4^* are the optimal quantities of x_2, x_3 and x_4 conditional on the level of specialized input x_1; and w_2, w_3 and w_4 are the prices of the non-specific inputs: labor, energy and capital, respectively. Specifically, the following equations are obtained: $x_2^* = x_2(x_1, w_2, w_3, w_4, p)$, $x_3^* = x_3(x_1, w_2, w_3, w_4, p)$ and $x_4^* = x_4(x_1, w_2, w_3, w_4, p)$.

Assuming that the non-specialized inputs are purchased in a perfectly competitive market, the new FOC in relation to the selection of x_1 is given by the following:

$$(5)\quad \begin{aligned} w_M &= -\theta \frac{\partial g(x_1, z)}{\partial x_1} x_1 + \\ &\quad p\frac{\partial f\left[x_1, x_2(x_1, w_2, w_3, w_4, p), x_3(x_1, w_2, w_3, w_4, p), x_4(x_1, w_2, w_3, w_4, p)\right]}{\partial x_1}. \end{aligned}$$

In other words, the FOC for profit maximization can be derived by simply differentiating the equation (4) with respect to x_1 and maintaining x_2, x_3 and x_4 at the levels optimally determined (an application of the Envelope Theorem). It should be noted that the marginal product is defined by the prices of the non-specialized inputs rather than the corresponding quantities.

Empirical Model

For the empirical application of the structural oligopsony model, it was assumed that the supply function for raw milk, equation (1), can be represented by a second-order approximation of a transcendental logarithmic function (translog), represented by the following:

$$(6)\quad \begin{aligned} \ln x_1 &= \beta_0 + \sum \beta_i \ln W_i + \phi_R \ln R + \delta T + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln W_i \ln W_j \\ &\quad + \sum_i \delta_{iT} \ln W_i T + \phi_{RT} \ln RT \end{aligned},$$

where W_i (i = M, C, Z, E) are, respectively, the price paid to farmers for raw milk (W_M), the price paid for feed (W_C), the price of live cattle (W_Z) and the exchange rate (W_E). R is the size of the herd and T is a time trend, specified to capture technical changes and other unobserved factors which affect the response of the raw milk supply in the short-term. Based on equation (6), it is possible to derive the price elasticity of the raw milk supply, given by the following:

$$(7)\quad \varepsilon = \frac{\partial \ln x_1}{\partial \ln W_M} = \beta_M + \sum_i \beta_{Mi} \ln W_i + \delta_{MT} T .$$

Considering the definition of the profit function for the dairy, given by equation (4), the marginal product of the dairy $\partial f(\cdot)/\partial x_1$ in (5) is also derived from an approximation of a translog function and is given by the following:

$$(8)\quad \frac{\partial f(\cdot)}{\partial x_1} = \frac{Y}{x_1}\left(\alpha_x + \alpha_{xx} \ln x_1 + \sum_{i=2}^{4} \alpha_{xi} \ln w_i + \alpha_{xp} \ln p\right)$$

where Y is the total output, x_1 is the amount of raw milk purchased and industrialized by the dairy industry, w_2 is the cost of labor in the dairy industry, w_3 is the cost of electricity in the industrial sector, w_4 is the cost of capital, measured by the real interest rate, and p is the price of the dairy product (at wholesale level).

Before proceeding with the definition of the model, however, it is necessary to assume a simplification in equation (8). Raw milk is the basic input in the production of several dairy products (fluid milk, cheese, butter, yoghurt, etc.). These products have different relevant markets and also different prices, so it would be impossible to group them into one single oligopsony model. To circumvent this problem, we assume a similar simplification used by Schroeter et al. (2000) and convert the quantity of dairy products Y into the equivalent liters of raw milk. This transformation means that $Y = x_1$, and the term Y/x_1 in (8) is canceled. Additionally, by applying this transformation, we are also obliged to place dairy product prices at the wholesale level p. Therefore, equation (8) becomes the following:

$$(9) \quad \frac{\partial f(\cdot)}{\partial x_1} = \alpha_x + \alpha_{xx} \ln x_1 + \sum_{i=2}^{4} \alpha_{xi} \ln w_i + \alpha_{xp} \ln p^*$$

where p^* is now the price of dairy products (at wholesale level) converted into equivalent liters of raw milk[5]. Based on (9), all of the components are available to define the FOC, given by equation (3). Using the equations (7) and (9), equation (3) is described by the following:

$$(10) \quad w_M = p^* \left(\alpha_x + \alpha_{xx} \ln x_1 + \sum_{i=2}^{4} \alpha_{xi} \ln w_i + \alpha_{xp} \ln p^* \right) \Bigg/ \left(1 + \frac{\theta}{\beta_M + \sum_i \beta_{Mi} \ln W_i + \delta_{MT} T} \right)$$

Equations (6) and (10) form a system of simultaneous equations for determining the degree of oligopsony power for the dairy industry in the purchase of raw milk. The econometric model is a nonlinear simultaneous equation system where the variables x_1, w_1 and p^* are jointly determined, and a term of disturbance is added to the two equations to allow for the existence of random shocks.

The nonlinear Generalized Method of Moments (GMM-NL) was used to estimate the model. The GMM is a robust estimator which, unlike the maximum-likelihood estimator, requires no information about the exact distribution of residuals (Gallant 1987). The heteroscedasticity and autocorrelation consistent (HAC) covariance matrix estimation also results in estimates that are robust to heteroscedasticity and autocorrelation in the residues. Thus, the traditional tests for detecting heteroscedasticity, autocorrelation and the distribution of residues are expendable. The only test required is the assessment of the validity of the restrictions of super-identification[6].

[5] The next section describes price conversion procedures.
[6] Moreover, in nonlinear regression models, the coefficient of determination R^2 loses value as a descriptive statistic for checking the quality of the model adjustment. The residual sum of squares plus the explained sum of squares is not necessarily equal to the total sum of squares. Therefore, the residual sum will not necessarily be equal to zero (Davidson and Mackinnom 2003).

Description of the Variables Used

The database used to estimate the structural model is a set of monthly data for covering the January/1997 to December/2011 period and gives a total 180 observations. Because of the restriction imposed on the geographical breadth of the relevant market, the data were obtained at the level of mesoregions (the most disaggregated level possible) so that tests could be carried out to delimit the relevant market. In total, information from fifteen Brazilian mesoregions was collected. The sample period and the regions analyzed were chosen according to data availability.

Figure 1 shows the distribution of the fifteen mesoregions in the sample. They are distributed over the six major milk producing states of Brazil – Rio Grande do Sul (3), Paraná (3), São Paulo (2), Minas Gerais (3), Goiás (2) and Santa Catarina (2) – which were responsible for 74% of national production in 2011. The twenty largest producers in Brazil are found in nine of these regions. Together, they produced 13.5 billion liters of raw milk in 2011, corresponding to 44% of the total Brazilian production (IBGE). The dairy industry collected 21.7 billion liters of raw milk throughout Brazil in 2011. In the fifteen mesoregions alone, 10.4 billion liters were collected, the equivalent of 47.7% of the total volume (IBGE).

Figure 1. Spatial distribution of the fifteen mesoregions selected.
Source. Drawn up by the authors

The variables used in the production function of raw milk are described below:

- Amount of raw milk (x_1) - monthly raw milk collected by the dairies in each mesoregion. The values are expressed in liters and were obtained from the Quarterly Milk Survey conducted by IBGE.

- Price of raw milk (w_M) - monthly average net price (after shipping rates and taxes) paid to farmers in each mesoregion. The values are expressed in R$/liter and were obtained from the Milk Bulletin, published by the Center for Advanced Studies in Applied Economics (CEPEA) at the *Universidade de São Paulo*[7].
- Price of feed (W_C) - monthly average price per kilogram of concentrated feed (R$/Kg) for dairy cows in the state of São Paulo; obtained from the database of the Institute of Agricultural Economics (IEA).
- Price of live cattle (W_Z) - monthly average price paid per *arroba* (unit of weight equal to 15 kg) of live cattle (R$/arroba) in the state of São Paulo; also obtained from the database of the Institute of Agricultural Economics (IEA).
- Exchange rate (W_E) - monthly average value of the commercial exchange rate, measured in nominal terms (R$/US$); published by the Brazilian Central Bank.
- Herd (R) - number of cows milked annually in each mesoregion analyzed, data provided by the Municipal Livestock Survey, conducted by IBGE. The data was interpolated (using a linear function) for conversion into a monthly series.

In addition to the price and quantity of raw milk, the following variables were used to estimate the demand function for raw milk by the dairy industry:

- Wage (w_2) – monthly average real wage index of Brazilian industry (for January/1997 = 100), obtained from the Institute of Applied Economic Research (IPEADATA).
- Energy (w_3) – monthly average price of electricity, charged per Megawatt/hour (R$/MWh) to the industrial sector, divided into the large Brazilian regions (South, Southeast and Midwest); released by the National Electrical Energy Agency (ANEEL).
- Capital (w_4) – monthly real interest rate, calculated as the difference between the Over/Selic rate provided by the Brazilian Central Bank, and the Consumer Price Index (IPCA) provided by IBGE.
- Prices of dairy products (p^*) – monthly price index calculated by a weighted average of the prices of dairy products at wholesale level, converted into the equivalent in raw milk. First, the following dairy products, milk powder, butter, cheese and other dairy products[8] were defined. They were converted into the equivalent in raw milk using the conversion table provided by the Brazilian Agricultural Research Corporation (EMBRAPA). Then, a weighted average price is calculated using the weight of each product in the international trade of dairy products (similar to the international price index of dairy products - DPI - published by FAO) as weighting factors. Table 1 summarizes the multiplication factors for conversion and the weight of each dairy product in the calculation of the price index.

[7] The series of prices paid for raw milk had to be interpolated because the research conducted by CEPEA started in 2004. Accordingly, between January 1997 and mid-2004 (the series were released as the mesoregions were being incorporated into the research), the price series of each mesoregion corresponds to the average price paid for raw milk in the State, which is provided by the *Fundação Getúlio Vargas*.

[8] Fluid milk in its many varieties is included.

Table 1. Multiplication and weighting factors used to calculate the weighted price index of dairy products, in equivalent raw milk

Dairy Products	Multiplication Factor[2]	Weighting Factor[3]
Milk powder	8.2	8.16%
Butter	1.65	9.16%
Cheese	10.0	12.81%
Other dairy products[1]	1.0	69.81%

Sources.
[1] Other dairy products include fluid milk, yoghurt, cream and condensed milk.
[2] Brazilian Agricultural Research Corporation (EMBRAPA);
[3] UN Food and Agriculture Organization (FAO).

The GMM needs instruments for parameter estimation other than the exogenous variables included in the equations of supply and demand, and so other variables were used as instruments in the estimation process: the international price index of dairy products released by FAO; the fuel price index, provided by *Fundação Getúlio Vargas* and two dummy variables – one covering the rainy season[9] and the other referring to the second half of 2007, which was characterized by increased prices on the international market.

All the variables representing monetary values were converted into real values by an aggregate price index, the Broad Consumer Price Index (IPCA), which is published by IBGE and defined as the official indicator of Brazilian inflation. All the series used were expressed in real values as of December/2011. In addition, the series were deseasonalized by the X12 method.

Estimation and Empirical Results

The definition of the relevant market, for both product and geographical region, is a key step in studies on market power (Sexton 2000) and was, therefore, the first step undertaken in this analysis. The relevant market for raw milk is the commercial relationship between farmers and the dairy industry in the marketing of raw milk. In terms of product, the relevant market is raw milk, which has no substitute. Geographically, two characteristics are essential in defining the market: perishability and transportation costs. These two characteristics significantly restrict the possible distance that raw milk can be transported from a farm to a dairy.

This restriction has been seen in the empirical literature. Perekhozhuk, Grins and Glauben (2009) claim that even if the adoption of cooling systems and bulk collection on the farm allowed raw milk to be transported to more distant regions, the geographical market in Ukraine does not exceed a radius of 150 km from the farm. Alvarez et al. (2000) also adopt the definition of a regional market (without specifying the distance) when they analyze the existence of oligopsony power in Spain. In Brazil, Conejero, Cônsoli and Neves (2006) found evidence for collection centers being situated close to dairies so as to minimize freight costs. In this context, we start with the hypothesis of a narrower geographic market (restricted to regional boundaries).

[9] During the rainy season, there tends to be a greater availability of fodder for livestock, which reduces the need for feed supplementation.

As explained, the database comprises a sample of fifteen producing mesoregions in Brazil. Raw milk production and collection in each of these regions is summarized in Table 2. It is noteworthy that raw milk collection by the dairies is greater than the amount produced only in four (North Central Paraná, East Central Paraná, Porto Alegre Metropolitan Area, and Central Goiás) of the fifteen mesoregions. In the other regions, the amount of raw milk collected is below the local production. This evidence supports the hypothesis of a market which is restricted to regional boundaries. However, additional statistical tests were carried out to corroborate this hypothesis.

Table 2. Raw milk production and collection in the selected mesoregions in 2011.

Region	**Mesoregion**	**Raw milk collection in 2011 (million liters) (A)**	**Prop. (%)**	**Raw milk production in 2011 (million liters) (B)**	**Prop. (%)**	**A/B (%)**
1	Triângulo Mineiro/Alto Paranaíba	1,949	8.94	2,093	6.82	93.12
2	Vale do Rio Doce	545	2.50	589	1.92	92.54
3	Southern/Southwestern Minas	919	4.22	1,361	4.43	67.51
4	São José do Rio Preto	190	0.87	345	1.12	55.10
5	Vale do Paraíba Paulista	197	0.91	212	0.69	93.18
6	North Central Paraná	257	1.18	237	0.77	108.48
7	East Central Paraná	504	2.31	433	1.41	116.44
8	Western Paraná	547	2.51	888	2.89	61.60
9	Western Santa Catarina	1,284	5.89	1,742	5.67	73.69
10	Vale do Itajaí	54	0.25	217	0.71	24.70
11	Northeastern Rio Grande do Sul	1,483	6.80	2,400	7.81	61.81
12	Northeastern Rio Grande do Sul	170	0.78	396	1.29	42.79
13	Porto Alegre Metropolitan Area	164	0.75	148	0.48	110.55
14	Central Goiás	1,267	5.81	809	2.63	156.75
15	Southern Goiás	882	4.05	1,655	5.39	53.30
	Total Sample	10,413	47.70	13,526	44.00	76.98
	Brazil	**21,799**	**100**	**30,715**	**100**	**70.97**

Source. Brazilian Institute of Geography and Statistics (IBGE)

Stationarity tests, serial correlation and co-integration[10] were applied to the series of prices paid for raw milk in the fifteen mesoregions. In all the tests, the hypothesis of markets larger than the borders of the mesoregions was statistically rejected. These results corroborate the existence of separate relevant markets restricted to regional borders (mesoregions). Although the market apparently stretched beyond its boundaries in four regions, there are no data on the neighboring regions to allow us to carry out aggregation tests. Accordingly, we assume that the fifteen mesoregions correspond to fifteen individual relevant markets for the raw milk trade.

[10] For further details of these tests, see Haldrup (2003) and Forni (2004)

Thus, the econometric model of oligopsony was estimated using the GMM-NL for each mesoregion, which resulted in a total of fifteen systems of nonlinear simultaneous equations. The results of the estimates are summarized in Table A (attached). As discussed earlier, the GMM estimator is robust and, unlike the maximum-likelihood estimator, requires no information about the exact distribution of residues (Gallant 1987).

Under the null hypothesis that the restrictions of over-identification are met, the validity test for the restrictions was performed by multiplying the value of the objective function $S(\theta,\hat{V})$ by the number of observations. The test is asymptotically distributed as χ^2, with the degrees of freedom equal to the number of over-identification constraints. The tests are recorded at the bottom of the table. It can be seen that the null hypothesis is not rejected in any of the models. Therefore, one can conclude that the estimated models are valid and the inference can be made.

The own-price elasticities for the supply of raw milk (ε) and the estimates of the conduct parameter (θ) of the oligopsony model are particularly interesting for estimates. These estimates are summarized in Table 3. The own-price elasticities of supply, obtained from equation (7) for each mesoregion, were calculated at the midpoint of the sample. The standard error and the p-value estimates were also informed. Only three of the fifteen estimates were statistically non-significant and some estimates showed a negative sign, contrary to the a priori expectation.

Table 3. Estimated results of the own-price elasticity of supply at the midpoint of the sample and conduct parameters.

Mesoregion	***ε***	**des-pad**	**p-value**	***θ***	**des-pad**	**p-value**
Triângulo Mineiro/Alto Paranaíba	0.273	0.074	0.00	0.000	0.001	0.430
Vale do Rio Doce	-0.219	0.033	0.00	**0.012**	**0.005**	**0.014**
Southern/Southwestern Minas	-0.138	0.023	0.00	**0.003**	**0.001**	**0.019**
São José do Rio Preto	0.059	0.032	0.07	0.018	0.018	0.301
Vale do Paraíba Paulista	-0.530	0.152	0.00	0.007	0.006	0.217
North Central Paraná	-0.724	0.163	0.00	**0.089**	**0.041**	**0.030**
East Central Paraná	0.824	0.535	0.13	-0.020	0.027	0.462
Western Paraná	-0.046	0.043	0.28	**0.004**	**0.002**	**0.057**
Western Santa Catarina	0.128	0.045	0.01	**-0.006**	**0.002**	**0.011**
Vale do Itajaí	0.403	0.074	0.00	**0.017**	**0.007**	**0.016**
Northwestern Rio Grande do Sul	-0.343	0.095	0.00	**0.005**	**0.002**	**0.018**
Northeastern Rio Grande do Sul	-0.172	0.036	0.00	**0.019**	**0.007**	**0.008**
Porto Alegre Metropolitan Area	1.212	0.199	0.00	0.016	0.012	0.173
Central Goiás	-0.412	0.086	0.00	**-0.013**	**0.007**	**0.057**
Southern Goiás	0.017	0.010	0.12	-0.002	0.002	0.215
Average	0.022			0.010		
Maximum	1.212			0.089		
Minimum	-0.724			-0.020		

Source. Research results

The negative sign of the own-price elasticity of supply could be a consequence of the constraints on the variables used (such as the technology shifter), or it could also be a result of the characteristics of the sector. According to Tauer and Kaiser (1988), there may be a downward sloping supply function for profit-maximizing firms facing a cash flow constraint. The necessary condition is that at least one of the factors be a no-cash input. The authors found empirical evidence that milk farmers commonly increase production even at lower prices by increasing, for example, the number of milkings performed per day.

Finally, with the exception of the Metropolitan mesoregion of Porto Alegre, all the estimates are smaller than unity. Therefore, the price elasticity of raw milk supply is inelastic. This characteristic is important because a high concentration of buyers in the relevant market and an inelastic supply of farmers are structural conditions conducive to the exercise of oligopsony power by dairies, as already documented by Sexton and Zhang (2001). Any distortion in the price offered by dairies has little impact in relation to a production adjustment for farmers, which enables the dairies to obtain higher profits.

With respect to the estimates of the degree of oligopsony power, not all estimates were within the interval of theoretical significance ($0 \leq \theta \leq 1$). In the mesoregions of East Central Paraná, Western Santa Catarina, Central Goiás and Southern Goiás, the estimates were negative, although only two were statistically significant. In six regions, the conduct parameters were not significantly different from zero. Thus, the assumption of perfect competition was not rejected. In other regions (in bold), the parameters were significantly different from zero at the 10% level of significance, but the estimated values were very small. The average value obtained was 0.01, while the maximum and minimum values were 0.089 and 0.02, respectively.

These results were close to those found by Hockmann and Võneki (2007) and Perekhozhuk, Grins and Glauben (2009). In the former, the authors indicated the existence of oligopsony power in the raw milk market in Hungary. However, the power of oligopsony was very small and the estimate of the parameter θ was equal to 0.001. Similarly, Perekhozhuk, Grins and Glauben (2009) found evidence of oligopsony power in only four of the twenty-three regions they analyzed in Ukraine. In the regions where the assumption of perfect competition was rejected, the estimates ranged from 0.007 to 0.022.

The results support the inference that oligopsony power is not a problem which significantly affects the Brazilian raw milk market. The estimates support the rejection of the hypothesis of monopsony in all the regions analyzed and the degree of distortion generated by oligopsony power, when identified, was small. This result is significant because it contradicts what is presented in the Parliamentary Inquiry reports on milk prices (ALRS 2002 and ALMG 2002) and also the discussion reported in the empirical literature, relating increasing concentration to increased oligopsony power in the dairy industry (Jank, Farina and Galan 1999; Martins and Faria 2006). Although the raw milk market could be concentrated and the dairies could have market power, the results support the existence of markets with the dynamics of perfect competition or at least close to perfect competition.

Although our results contradict common sense, there is certain evidence to corroborate our findings, which therefore gives greater support to our conclusions. One such is the possibility of competition through imports (market contestability). As previously discussed, Barros et al. (2004) and Santos and Barros (2006), found evidence that imports are brought in with sufficient frequency to supply the domestic market and influence domestic prices. So, because domestic prices tend to follow international prices, this creates a certain rigidity in the capacity of the dairies to fix prices.

Secondly, the informal marketing of raw milk and the idle capacity of the dairy industry are two factors which restrict the possibility of collusive action on the part of the dairies. Bánkuti, Schiavi and Souza Filho (2005) found evidence that there is an informal market not only in small but also in medium-sized farms, and that farmers operate simultaneously in both. In addition, we also found various cases of small farmers getting together to produce dairy products on the farm itself to sell in regional markets and fairs.

In this scenario therefore, there is keen competition between the dairies for milk producers and any price manipulation could lead to a loss of these suppliers. Although there are no data for the industry as a whole, Barros et al. (2004) found evidence that the dairies award bonuses for production volume. This is a clear strategy for holding on to large milk producers and is totally contrary to the hypothesis of the exercise of oligopsony power.

Conclusion

The purpose of this study was to measure the degree of oligopsony power in the Brazilian raw milk market. After defining the relevant market, the econometric model was estimated at the level of mesoregion. The results did not indicate the existence of any large distortions caused by oligopsony power. The estimates led to the rejection of the hypothesis of monopsony in all the regions analyzed and, in general, the conduct parameter estimates were close to zero, which would indicate markets whose dynamics are very close to those of perfectly competitive markets.

This result is significant because it contradicts the suspicions of market power, found in investigations carried out by the milk price Parliamentary Inquiries and it also contradicts the discussion in the literature that increased market concentration led to an increase in the market power of dairies. Even if the raw milk market is concentrated on the part of the dairies, the evidence does not support the hypothesis that they distort the market by imposing prices lower than those that would be paid in a competitive market.

Finally, we wish to emphasize that this study is limited to an analysis of market power in the supply chain link, represented by the relationship between farmer and dairy, in the supply of raw milk, hence the conclusion that the problem of market power is not relevant, and cannot be extended to the supply chain as a whole. If there are distortions in other links, they tend to be transmitted along the entire chain. Thus, an investigation of other links in the milk supply chain is to be recommended.

Acknowledgements

The authors gratefully acknowledge the financial support of the Research Foundation of the State of Goias (FAPEG) and the National Council for Scientific and Technological Development (CNPq).

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Appendix

Table A. Estimated results of the simultaneous equation system of the oligopsony model

Part 1.

	Tr. Mineiro/A. Paranaíba			Vale do Rio Doce			Southern/South-western Minas			São José do Rio Preto			Vale do Paraíba Paulista		
Param	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val
β_0	33.36	17.21	0.05	-33.31	16.94	0.05	-24.41	7.42	0.00	26.13	9.67	0.01	-47.74	17.72	0.01
β_M	-1.04	0.33	0.00	-4.86	0.73	0.00	11.91	2.04	0.00	8.22	3.06	0.01	-15.38	4.36	0.00
β_C	0.49	4.20	0.91	3.64	5.35	0.50	-0.36	2.83	0.90	-12.30	4.12	0.00	0.12	4.34	0.98
β_Z	-4.29	7.18	0.55	21.66	7.43	0.00	8.88	2.85	0.00	4.51	5.33	0.40	41.55	8.47	0.00
β_E	3.17	2.64	0.23	-3.19	3.13	0.31	8.82	1.81	0.00	7.04	2.11	0.00	-9.34	3.45	0.01
β_R	-0.78	0.35	0.03	0.38	0.25	0.13	1.96	0.34	0.00	-1.47	0.38	0.00	-1.86	0.53	0.00
δ	-0.15	0.08	0.08	0.08	0.06	0.21	-0.24	0.06	0.00	-0.13	0.04	0.00	-0.34	0.08	0.00
β_{MM}	-0.14	0.04	0.00	-1.47	0.22	0.00	6.62	1.11	0.00	-7.79	2.09	0.00	12.78	3.67	0.00
β_{MC}	3.82	1.06	0.00	1.73	0.27	0.00	2.30	0.39	0.00	8.82	2.37	0.00	-11.68	3.33	0.00
β_{MZ}	0.19	0.06	0.00	0.79	0.12	0.00	-1.19	0.21	0.00	-2.63	0.87	0.00	4.52	1.29	0.00
β_{ME}	0.98	0.28	0.00	-0.02	0.01	0.28	-2.13	0.36	0.00	-2.59	0.73	0.00	5.98	1.70	0.00
β_{CC}	-2.13	1.41	0.13	-2.75	1.26	0.03	0.74	0.78	0.34	-8.67	2.51	0.00	8.06	3.19	0.01
β_{CZ}	0.69	0.98	0.48	-0.36	1.20	0.77	0.69	0.66	0.30	3.67	1.04	0.00	-1.07	1.19	0.37
β_{CE}	-0.49	0.36	0.18	-0.38	0.47	0.41	-0.20	0.36	0.58	2.72	1.07	0.01	-3.56	1.31	0.01
β_{ZZ}	1.44	1.69	0.39	-5.33	1.64	0.00	-2.01	0.69	0.00	-1.19	1.22	0.33	-9.89	1.96	0.00
β_{ZE}	-0.46	0.61	0.45	0.78	0.74	0.29	-2.57	0.46	0.00	-1.61	0.47	0.00	2.83	0.96	0.00
β_{EE}	-0.92	0.44	0.04	0.87	0.43	0.04	0.19	0.24	0.44	-1.80	0.66	0.01	2.55	0.73	0.00
δ_{MT}	-2.27×10^{-3}	0.00	0.00	1.57×10^{-3}	0.00	0.00	-2.52×10^{-2}	0.00	0.00	2.20×10^{-2}	0.01	0.00	-3.50×10^{-2}	0.01	0.00
δ_{CT}	-1.27×10^{-2}	0.00	0.00	-3.15×10^{-3}	0.00	0.39	-1.36×10^{-2}	0.00	0.00	-1.49×10^{-2}	0.00	0.00	1.81×10^{-2}	0.01	0.02
δ_{ZT}	-1.37×10^{-2}	0.00	0.00	1.05×10^{-2}	0.00	0.00	9.58×10^{-3}	0.00	0.00	-6.45×10^{-5}	0.00	0.98	1.67×10^{-2}	0.00	0.00
δ_{ET}	3.42×10^{-4}	0.00	0.86	-9.16×10^{-3}	0.00	0.00	1.51×10^{-2}	0.00	0.00	5.79×10^{-3}	0.00	0.00	-2.92×10^{-2}	0.01	0.00
δ_{RT}	1.54×10^{-2}	0.01	0.02	-8.18×10^{-3}	0.01	0.11	1.28×10^{-2}	0.00	0.00	1.03×10^{-2}	0.00	0.00	2.19×10^{-2}	0.01	0.00
α_x	-3.91×10^{-2}	0.01	0.00	-1.38×10^{-1}	0.02	0.00	-5.75×10^{-2}	0.01	0.00	-4.72×10^{-2}	0.02	0.04	8.28×10^{-2}	0.02	0.00
α_{xx}	9.61×10^{-4}	0.00	0.04	3.03×10^{-4}	0.00	0.61	9.16×10^{-4}	0.00	0.12	1.29×10^{-3}	0.00	0.28	-5.15×10^{-3}	0.00	0.00
α_{x2}	2.73×10^{-3}	0.00	0.06	1.66×10^{-2}	0.00	0.00	3.81×10^{-3}	0.00	0.00	7.50×10^{-3}	0.00	0.00	3.78×10^{-3}	0.00	0.08
α_{x3}	-5.40×10^{-4}	0.00	0.22	-1.01×10^{-3}	0.00	0.35	-5.08×10^{-4}	0.00	0.14	-2.62×10^{-4}	0.00	0.82	-1.51×10^{-3}	0.00	0.00
α_{x4}	-6.98×10^{-4}	0.00	0.00	1.29×10^{-4}	0.00	0.62	-2.77×10^{-4}	0.00	0.04	-3.18×10^{-4}	0.00	0.38	1.77×10^{-4}	0.00	0.47
α_{xp^*}	3.88×10^{-3}	0.00	0.12	1.36×10^{-2}	0.00	0.00	6.78×10^{-3}	0.00	0.00	-3.12×10^{-4}	0.00	0.85	-1.78×10^{-4}	0.00	0.90
θ	0.00	0.00	0.43	0.01	0.00	0.01	0.00	0.00	0.02	0.02	0.02	0.30	0.01	0.01	0.22
$s(\varepsilon,\hat{\nu})$	0.0937			0.1266			0.1208			0.0997			0.1081		
Over-id	16.87		0.99	22.78		0.99	21.74		0.99	17.94		0.99	19.46		0.99

Source. Research results

Table A. Estimated results of the simultaneous equation system of the oligopsony model-*Cont.*

Part 2.

	North Central Paraná			East Central Paraná			Western Paraná			Western Santa Catarina			Vale do Itajaí		
Param.	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val
β_0	290.95	59.47	0.00	-368.65	167.98	0.03	57.91	13.18	0.00	84.65	20.40	0.00	-181.22	22.41	0.00
β_M	75.92	13.31	0.00	-26.97	13.11	0.04	13.31	3.63	0.00	20.26	7.02	0.00	-12.27	2.58	0.00
β_C	35.58	15.61	0.02	-42.02	27.81	0.13	7.16	2.41	0.00	8.60	3.89	0.03	0.52	4.72	0.91
β_Z	-120.02	28.27	0.00	176.59	65.25	0.01	-7.64	5.03	0.13	-9.62	5.54	0.08	-11.41	5.79	0.05
β_E	45.29	6.95	0.00	-46.05	14.43	0.00	1.76	1.66	0.29	4.95	3.42	0.15	-0.07	3.05	0.98
β_R	-0.33	2.13	0.88	1.82	4.92	0.71	-1.68	0.29	0.00	-3.17	1.33	0.02	19.15	1.66	0.00
δ	-0.42	0.25	0.10	-0.43	0.36	0.24	-0.18	0.04	0.00	-0.41	0.13	0.00	1.10	0.14	0.00
β_{MM}	3.33	1.10	0.00	18.76	7.02	0.01	-1.05	0.34	0.00	1.39	0.49	0.00	-6.01	0.94	0.00
β_{MC}	13.84	2.51	0.00	-25.60	8.29	0.00	1.52	0.41	0.00	5.03	1.75	0.00	-7.49	1.07	0.00
β_{MZ}	-19.01	3.32	0.00	10.70	3.97	0.01	-3.34	0.91	0.00	-3.79	1.31	0.00	1.16	0.50	0.02
β_{ME}	9.91	1.79	0.00	-2.15	3.21	0.50	1.39	0.38	0.00	-0.67	0.24	0.01	-1.30	0.24	0.00
β_{CC}	8.06	3.93	0.04	5.87	4.91	0.23	2.95	0.97	0.00	1.42	1.62	0.38	5.44	1.65	0.00
β_{CZ}	-4.63	3.06	0.13	5.39	5.41	0.32	-0.85	0.51	0.10	-0.64	1.07	0.55	-0.98	1.09	0.37
β_{CE}	-2.00	1.13	0.08	-2.92	2.28	0.20	-2.13	0.28	0.00	-0.28	0.55	0.61	-1.13	0.59	0.06
β_{ZZ}	26.30	6.31	0.00	-42.07	15.28	0.01	1.22	1.07	0.25	1.78	1.29	0.17	2.52	1.30	0.05
β_{ZE}	-9.66	1.63	0.00	9.98	3.21	0.00	-0.31	0.39	0.43	-1.62	0.85	0.06	-0.43	0.75	0.57
β_{EE}	0.92	0.95	0.33	4.83	2.56	0.06	0.44	0.27	0.10	0.18	0.38	0.64	2.38	0.59	0.00
δ_{MT}	$1.81\text{x}10^{-2}$	0.00	0.00	$-1.09\text{x}10^{-1}$	0.04	0.00	$-2.76\text{x}10^{-3}$	0.00	0.01	$-2.37\text{x}10^{-2}$	0.01	0.00	$5.02\text{x}10^{-2}$	0.01	0.00
δ_{CT}	$-6.51\text{x}10^{-2}$	0.01	0.00	$7.41\text{x}10^{-2}$	0.02	0.00	$-1.24\text{x}10^{-2}$	0.00	0.00	$-2.66\text{x}10^{-2}$	0.01	0.00	$-1.15\text{x}10^{-3}$	0.00	0.79
δ_{ZT}	$7.56\text{x}10^{-3}$	0.01	0.15	$6.37\text{x}10^{-2}$	0.02	0.00	$7.28\text{x}10^{-3}$	0.00	0.01	$8.90\text{x}10^{-3}$	0.01	0.13	$1.32\text{x}10^{-2}$	0.00	0.00
δ_{ET}	$1.55\text{x}10^{-2}$	0.01	0.01	$-3.81\text{x}10^{-2}$	0.01	0.00	$1.45\text{x}10^{-3}$	0.00	0.41	$1.76\text{x}10^{-2}$	0.00	0.00	$-8.82\text{x}10^{-3}$	0.00	0.00
δ_{RT}	$3.19\text{x}10^{-2}$	0.02	0.14	$1.20\text{x}10^{-2}$	0.03	0.73	$1.25\text{x}10^{-2}$	0.00	0.00	$2.81\text{x}10^{-2}$	0.01	0.00	$-9.92\text{x}10^{-2}$	0.01	0.00
α_x	$-1.85\text{x}10^{-2}$	0.01	0.06	$-4.69\text{x}10^{-2}$	0.00	0.00	$-6.53\text{x}10^{-3}$	0.01	0.27	$-7.37\text{x}10^{-3}$	0.01	0.25	$-3.29\text{x}10^{-2}$	0.01	0.00
α_{xx}	$-9.12\text{x}10^{-4}$	0.00	0.01	$1.53\text{x}10^{-3}$	0.00	0.00	$2.56\text{x}10^{-3}$	0.00	0.00	$1.94\text{x}10^{-3}$	0.00	0.00	$-1.55\text{x}10^{-4}$	0.00	0.68
α_{xz}	$1.99\text{x}10^{-3}$	0.00	0.25	$4.40\text{x}10^{-4}$	0.00	0.64	$-4.00\text{x}10^{-3}$	0.00	0.00	$-3.52\text{x}10^{-4}$	0.00	0.77	$8.25\text{x}10^{-3}$	0.00	0.00
α_{xd}	$2.21\text{x}10^{-3}$	0.00	0.02	$1.10\text{x}10^{-3}$	0.00	0.00	$-1.83\text{x}10^{-3}$	0.00	0.00	$-1.39\text{x}10^{-3}$	0.00	0.00	$5.09\text{x}10^{-4}$	0.00	0.42
α_{xd}	$5.28\text{x}10^{-4}$	0.00	0.05	$-2.07\text{x}10^{-4}$	0.00	0.07	$1.00\text{x}10^{-4}$	0.00	0.30	$-7.03\text{x}10^{-4}$	0.00	0.00	$-5.02\text{x}10^{-4}$	0.00	0.01
α_{xq^*}	$3.83\text{x}10^{-3}$	0.00	0.00	$4.22\text{x}10^{-3}$	0.00	0.00	$-5.92\text{x}10^{-4}$	0.00	0.41	$-2.45\text{x}10^{-3}$	0.00	0.00	$-2.03\text{x}10^{-4}$	0.00	0.87
θ	0.09	0.04	0.03	-0.02	0.03	0.46	0.00	0.00	0.06	-0.01	0.00	0.01	0.02	0.01	0.02
$s(e,\hat{v})$	0.1266			0.1063			0.1356			0.0925			0.1296		
Over-id	22.79		0.99	19.17		0.99	24.41		0.99	16.65		0.99	23.34		0.99

Source. Research results

Table A. Estimated results of the simultaneous equation system of the oligopsony model-*Cont*

Part 3.

	Northwestern Rio Grande do Sul			Northeastern Rio Grande do Sul			Porto Alegre Metropolitan Area			Central Goiás			Southern Goiás		
Param.	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val	Est.	stand-error	p-val
β_0	37.66	13.09	0.00	33.09	15.47	0.03	-109.97	32.72	0.00	-64.43	15.05	0.00	-61.95	17.33	0.00
β_M	0.76	0.23	0.00	47.19	8.30	0.00	-20.29	3.49	0.00	-11.14	2.27	0.00	0.70	0.36	0.06
β_C	18.22	2.89	0.00	11.54	2.95	0.00	4.25	5.60	0.45	13.00	3.38	0.00	-8.55	4.55	0.06
β_Z	-18.46	5.28	0.00	-7.37	6.96	0.29	20.52	10.39	0.05	36.07	8.66	0.00	24.54	5.84	0.00
β_E	9.78	2.12	0.00	13.50	2.58	0.00	8.13	4.74	0.09	-3.69	2.91	0.21	-2.37	1.72	0.17
β_R	1.22	0.54	0.02	0.97	0.44	0.03	6.56	1.92	0.00	0.22	0.99	0.83	2.13	0.76	0.01
δ	-0.05	0.04	0.27	0.08	0.10	0.45	0.43	0.19	0.03	-0.26	0.10	0.01	0.20	0.05	0.00
β_{MM}	-0.03	0.04	0.36	-6.33	1.22	0.00	-16.37	2.69	0.00	5.72	1.16	0.00	1.71	0.86	0.05
β_{MC}	-0.71	0.22	0.00	5.38	1.10	0.00	7.16	1.15	0.00	-2.37	0.48	0.00	-2.14	1.07	0.05
β_{MZ}	-0.68	0.19	0.00	-11.91	2.09	0.00	2.93	0.53	0.00	3.65	0.73	0.00	-0.05	0.03	0.09
β_{ME}	1.25	0.35	0.00	0.73	0.24	0.00	-4.78	0.77	0.00	0.05	0.06	0.33	0.60	0.30	0.05
β_{CC}	6.22	0.98	0.00	6.24	1.31	0.00	3.90	1.97	0.05	6.03	1.32	0.00	1.61	1.70	0.34
β_{CZ}	-3.87	0.65	0.00	-1.09	0.60	0.07	0.70	1.19	0.56	-2.59	0.76	0.00	1.94	0.98	0.05
β_{CE}	-0.78	0.32	0.01	-1.87	0.44	0.00	-1.24	0.62	0.05	-2.81	0.33	0.00	-1.72	0.47	0.00
β_{ZZ}	4.50	1.18	0.00	0.23	1.56	0.88	-3.93	2.31	0.09	-8.03	1.98	0.00	-5.91	1.34	0.00
β_{ZE}	-2.03	0.50	0.00	-3.71	0.66	0.00	-3.03	1.21	0.01	0.46	0.70	0.51	0.27	0.43	0.54
β_{EE}	-0.85	0.46	0.06	1.26	0.53	0.02	0.02	0.59	0.97	1.61	0.49	0.00	1.79	0.50	0.00
δ_{MT}	$1.10x10^{-2}$	0.00	0.00	$1.16x10^{-2}$	0.00	0.00	$3.07x10^{-2}$	0.01	0.00	$-3.16x10^{-2}$	0.01	0.00	$-4.59x10^{-4}$	0.00	0.10
δ_{CT}	$-1.13x10^{-2}$	0.00	0.00	$-2.92x10^{-2}$	0.01	0.00	$-2.58x10^{-2}$	0.00	0.00	$-4.57x10^{-3}$	0.00	0.19	$4.21x10^{-3}$	0.00	0.19
δ_{ZT}	$-1.84x10^{-3}$	0.00	0.51	$2.99x10^{-2}$	0.00	0.00	$-1.07x10^{-2}$	0.01	0.13	$8.26x10^{-3}$	0.00	0.03	$5.51x10^{-3}$	0.00	0.06
δ_{ET}	$6.21x10^{-3}$	0.00	0.00	$2.52x10^{-2}$	0.00	0.00	$3.27x10^{-2}$	0.00	0.00	$5.21x10^{-3}$	0.00	0.04	$1.10x10^{-3}$	0.00	0.53
δ_{RT}	$4.40x10^{-3}$	0.00	0.18	$-1.74x10^{-2}$	0.01	0.06	$-3.43x10^{-2}$	0.02	0.02	$1.60x10^{-3}$	0.01	0.05	$-1.61x10^{-2}$	0.00	0.00
α_c	$3.98x10^{-3}$	0.01	0.55	$-2.02x10^{-2}$	0.00	0.00	$-5.56x10^{-2}$	0.01	0.00	$-1.43x10^{-2}$	0.01	0.06	$-3.09x10^{-2}$	0.01	0.00
α_{cc}	$1.85x10^{-3}$	0.00	0.00	$1.22x10^{-4}$	0.00	0.63	$1.28x10^{-4}$	0.00	0.67	$1.34x10^{-3}$	0.00	0.00	$-1.33x10^{-4}$	0.00	0.76
α_{c2}	$-5.39x10^{-3}$	0.00	0.00	$4.08x10^{-3}$	0.00	0.00	$1.08x10^{-2}$	0.00	0.00	$-1.12x10^{-3}$	0.00	0.49	$4.74x10^{-3}$	0.00	0.00
α_{c3}	$-1.30x10^{-3}$	0.00	0.00	$3.80x10^{-4}$	0.00	0.55	$-1.19x10^{-4}$	0.00	0.84	$-1.04x10^{-3}$	0.00	0.09	$-2.83x10^{-5}$	0.00	0.95
α_{c4}	$-1.83x10^{-5}$	0.00	0.90	$-4.59x10^{-4}$	0.00	0.01	$-7.84x10^{-5}$	0.00	0.73	$-2.66x10^{-4}$	0.00	0.11	$-1.40x10^{-3}$	0.00	0.00
α_{cp^*}	$1.41x10^{-4}$	0.00	0.87	$5.74x10^{-4}$	0.00	0.59	$1.85x10^{-3}$	0.00	0.05	$1.57x10^{-3}$	0.00	0.36	$3.85x10^{-3}$	0.00	0.00
θ	0.00	0.00	0.02	0.02	0.01	0.01	0.02	0.01	0.17	-0.01	0.01	0.06	0.00	0.00	0.21
$s(\hat{e},\hat{v})$	0.1062			0.1019			0.1211			0.1212			0.0938		
Over-id	19.11		0.99	18.34		0.99	21.80		0.99	21.82		0.99	16.88		0.99

Source. Research results

International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

U.S. and Canadian Consumer Perception of Local and Organic Terminology

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Abstract

The varying terms associated with local and organic have the potential to confuse consumers as to their true meaning, especially with respect to production practices. For these reasons we examined the perceptions and misperceptions of the terms local and organic, specifically focusing on differences between U.S. and Canadian consumers. Our results show that a subset of consumers correctly identifies the main characteristics of local and organic. However, there is a subset of consumers that has inaccurate perceptions of these terms. Comparing U.S. and Canadian consumers we see numerous significant perception differences, especially with regard to local.

Keywords: consumer perception, local, organic, survey

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Introduction

The words local and organic have become common terminology within marketing campaigns throughout the world. These terms have found a special place within the lexicon of the United States and Canada as evidenced by large displays and merchandise areas devoted to promoting the sale of local and organic foods. As such, regulations have been enacted both in the U.S. and Canada to standardize definitions of local and organic. For instance, the U.S. government defines local (or regionally produced) as "(I) the locality or region in which the final product is marketed, so that the total distance that the product is transported is less than 400 miles from the origin of the product" or ''(II) the state in which the product is produced." (H.R. 6124 2008), while many state governments have limited the term local to mean produced within state boundaries. With respect to Canada, the Canadian Food Inspection Agency (CFIA) is in the process of changing their definition of local food, but the interim definition is similar to the U.S. definition in that it must be "produced in the province or territory in which it is sold, or ...sold across provincial borders within 50 km of the originating province or territory." (CFIA 2013). However, as noted in a litany of previous studies, these definitions may not be appropriate in many instances (Carter-Whitney 2008; Martinez el al. 2010; Campbell, Mhlanga, and Lesschaeve 2013; Johnson, Aussenberg and Cowan 2013). Organic, on the other hand, has defined production standards that are similar across the U.S. and Canada, see Canadian General Standards Board 2011a, 2011b; United States Department of Agriculture-Agricultural Marketing Service 2013.

Retail sales of both local and organic products have seen increasing demand over the last decade. Sales of organic products in the U.S. and Canada topped $26.7 billion and $2.6 billion in 2010, respectively (Organic Trade Association 2011; Globe and Mail 2011). Exact sales figures for locally sourced products are more challenging to acquire given the lack of local sales tracking by many retailers. However, recent estimates indicate that sales of products labeled as locally grown were $4.8 billion in the U.S. during 2008 (Low and Vogel 2011).

Viewing the increasing retail sales of local and organic at face value tends to indicate a strong and vibrant sector, but do consumers understand what they are purchasing? Not considering altruistic characteristics, such as helping the community or farmer, do consumers know what production related characteristics are inherent in local and organic food? For organic, government-mandated regulations exist in both Canada and the U.S. that dictate specific production practices. For the most part, Canadian and U.S. regulations align, especially for broad characteristics, such as "no synthetic pesticides used." However, regulations for local generally imply distance boundaries with no regulations on production practices. In both cases, there is considerable variety with what consumers perceive as local and organic compared to what regulations say it can and cannot be (Shipman 2012; Campbell, Mhlanga, and Lesschaeve, 2013).

Thereby, similar to Campbell, Mhlanga, and Lesschaeve (2013), the objective of this study was to both understand consumer perceptions of the terms local and organic and to understand the role of demographic, socio-economic, and purchasing behavior on consumer perception. However, unlike Campbell, Mhlanga, and Lesschaeve (2013), we focus our attention toward differences between U.S. and Canadian consumers. Given the considerable trade between the

U.S. and Canada, understanding differences in consumer perception within these markets is critical since producers and marketers are increasingly marketing products across this border. Furthermore, we examine the role of consumer characteristics on the perception of local and organic products being perceived as higher priced. Our results indicate that indeed U.S. and Canadian consumers do have many differing perceptions of local and organic especially with respect to local, providing helpful information to markets selling products with these terms. Using this information, agribusiness firm managers can gain a better understanding on how consumers in two markets perceive the terms local and organic. This information, and the corresponding consumer profiles, can be used to either develop marketing strategies to effectively deliver specific messaging to consumers that value it or to deliver educational programs that change perceptions.

Literature Review

Literature around the perceived value and definitions of local and organic labeling is widespread. For instance, numerous studies have found consumers are willing to pay a price premium for locally (e.g. Darby et al. 2008; Yue and Tong 2009; Onozaka and McFadden 2011) and organically (e.g. Batte et al. 2007; Campbell et al. 2010) labeled products. Given the heterogeneous nature of the market, research efforts have attempted to better understand how consumer characteristics might influence a consumer's propensity to purchase local and organic products (e.g. Zhang et al. 2008; Smith, Huang, and Lin 2009; Campbell et al. 2010). Just as the propensity to purchase varies across consumer characteristics, so too do consumer perceptions of local and organic. For instance, attributes such as fresher and supports the local farmer/ community consistently arise as important reasons to purchase local (Darby et al. 2008; Yue and Tong 2009; Onozaka et al. 2010). Conversely, reasons for purchasing organic tend to be centered around environmental and safety concerns (Ritson and Oughton 2007; Essoussi and Zahaf 2008). Still, when examining actual production practices associated with local and organic, consumers, or at least a subset thereof, tend to have inaccurate perceptions. As noted by Ipsos Reid (2006), 5% of Canadian consumers perceive local as having no chemicals or synthetic pesticides and 5% say it is not genetically modified (GMO). In light of the regulations around local, these perceptions are inaccurate as local is most often defined by governmental sources as some geographic delineation.

Consistent with the Ipsos Reid (2006) findings, Campbell, Mhlanga, and Lesschaeve (2013) found that many Canadian consumers have inaccurate perceptions of the production practices surrounding the local and organic foods they purchase. Of interest between these two studies is that the misperception about chemical/pesticide use and non-genetically modified nature of local seems to have doubled from 5% and 5% in 2006 (Ipsos Reid 2006) to 11% and 13% in 2010 (Campbell, Mhlanga, and Lesschaeve, forthcoming), respectively. However, little is known about the [mis]perceptions of U.S. consumers and any potential differences between U.S. and Canadian consumers.

Data

During the spring 2011, we launched an online survey to better assess the market for horticultural products in the U.S. and Canada. Utilizing Global Market Insite, Inc.'s (GMI) database of U.S. and Canadian consumers, potential respondents were contacted via email and invited to participate in the survey. Respondents willing to participate were directed to an online survey link and proceeded to take the survey. A total of 2,511 consumers were surveyed with 68% and 32% of respondents being from the U.S. and Canada, respectively. Each contiguous U.S. state and Canadian province was represented within the survey. The demographics of our sample (see Table 1) were similar to the average census demographics for the U.S. and Canada. Our U.S. sample's average age (35.8) and percent Caucasian (78.1%) were similar to the census reported average age (37.2) and percent Caucasian (78.1%), respectively. Average household income ($65,273) was significantly higher than the average census household income ($52,762).

Table 1. Descriptive statistics for the variables of interest by country.

Variables	**U.S.**	**Canada**
Number of observations	1,716	809
Age	35.76	42.74
Adults in household	2.62	2.47
Children in household	1.69	1.61
Household income	$65,273	$66,747
Gender (1=male)	0.58	0.49
Urban	0.21	0.40
Suburb	0.59	0.40
Rural	0.20	0.20
Education		
High school or less	0.20	0.20
Between high school and 4-year	0.42	0.41
Bachelor's degree	0.27	0.28
Greater than bachelor's	0.11	0.11
Race (1=Caucasian)	0.78	0.86
Heard of term		
Eco-friendly (1=yes)	0.92	0.95
Sustainable (1=yes)	0.73	0.76
Frequency of purchasing when available [1]		
Local produce	3.24	3.49
Organic produce	2.81	2.70
Recycling index [2]	2.89	3.43

[1] Frequency of purchasing : 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[2] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.

In regard to the Canadian sample, the average age (42.7) and household income ($66,747) were similar to the census reported average age (39.7) and household income ($69,860). For the ethnicity question, we used the U.S. census question which is different from the Canadian census question, thereby; a direct comparison between the percent Caucasian in our sample and amongst the Canadian population is not possible. However, rough calculations based on the ethnic heritages reported in the Canadian census indicate that 80% of people in Canada would fall in the Caucasian group compared to 86% in our sample.

The survey asked a variety of questions around purchasing and recycling patterns, along with traditional demographic and socio-economic questions. Demographic questions included income, education, marital status, age, gender, household characteristics, and ethnicity. Purchase behavior questions consisted of whether they were the primary shopper in the household, the types of stores generally shopped in, and their purchasing of local and organic produce. Recycling questions revolved around frequency of recycling of a number of recyclable materials. Also, respondents were shown a list of potential local and organic characteristics (Table 2). They were then asked to mark any and all characteristics that they perceived characterized a local product. Then they were asked to mark any and all characteristics they perceived to be associated with an organic product.

Methodology

In order to examine whether U.S. and Canadian consumers are different with regards to their perceptions, we utilized a t-test as a preliminary indicator of statistical difference. However, we not only wanted to understand whether there are statistical differences, but we also wanted to have an idea of the impact of consumer characteristics on perception. We, therefore, ran binary logit models to assess the role of consumer characteristics on consumer perception of local and organic. Given respondents were asked to denote characteristic(s) from the list provided as being a characteristic of local in general, then organic in general, each characteristic received a binary coding of 1 if the respondent indicated the characteristic was associated with local or 0 if the characteristic was not associated with local. Since the dependent variable is categorical in nature, i.e. 0 or 1, the binary logit model is an appropriate modeling technique. After coding each characteristic for local, we ran a binary logit model with each characteristic as a dependent variable and consumer characteristics as predictors. The subsequent binary logit probability for each characteristic can be modeled as

$$1) \qquad P_i = \frac{1}{1+e^{-x_i'}}\beta$$

where P_i is the probability of the i^{th} respondent choosing the characteristic from Table 2 and x_i is a set of demographic, environmental variables, and purchasing behaviors associated with the i^{th} respondent. Environmental variables included: recycling index and having heard of the terms eco-friendly and sustainable. The recycling index variable is used as an indicator of respondent’s environmental concern/activity and is calculated as the mean of the respondent’s frequency of recycling (as measured by a rating scale) of aluminum, glass, and cardboard. Having heard of eco-friendly and sustainable were included as proxies for environmental awareness. After specifying the model, we examined whether the U.S. and Canadian respondents could be pooled together. Based on the results of likelihood ratio tests of the equality of coefficients we could not pool the U.S. and Canadian sample. Thereby, we analyzed the respondents separately and present the results for both the U.S. and Canadian respondents. After running the binary logit models, we estimated the marginal effects for each consumer characteristic as the marginal effects are easier to interpret than the log-likelihoods from the initial binary logit output.

The marginal effects are interpreted differently depending on whether it is used to explain a binary or continuous variable. For a continuous variable, the interpretation is that for a one unit increase from the mean, there is a percentage, as defined by the marginal effect associated with the variable, change in the likelihood of perceiving the characteristic is associated with local. For dummy variables, the interpretation is that moving from the base category to the category in question, there is a corresponding percentage change in the likelihood of the characteristic being associated with local. After obtaining the marginal effects for the first characteristic, we proceeded to model all the other characteristics using a binary logit model, then moving on to each organic characteristic using a similar procedure.

Results

In Table 2, we see that our overall results are similar to those of Campbell, Mhlanga, and Lesschaeve (2013) with respect to consumers having both accurate (such as local means lower miles to transport and organic implies no synthetic pesticide use) and inaccurate (such as local is organic, organic is local, local means no pesticide use, and organic implies lower miles to transport) perceptions of local and organic. For instance, 67% of the total sample correctly perceives decreased miles to transport as a characteristic of local. However, 23% and 17% of the total sample inaccurately perceive local as being grown organically and without synthetic pesticide use, respectively. The organic results show 67% of the total sample perceived organic as produced with no synthetic pesticides, but approximately one in five (17%) believe local is a characteristic of organic. The importance of these results to agribusiness firms is considerable. Take for example the organic industry that has spent years (and millions of dollars) building brand awareness and now sees as much as 17% of the consumer base mistakenly associating local with organic. This fact has not been lost on organic growers/associations. As noted by the Canadian Organic Growers website, “Sadly, ‘local’ and ‘organic’ have had the misfortune of entering our vocabulary as separate concepts and then getting jumbled into one, unclear concept.” There is reason for concern. Assuming only a small share of consumers now purchase local believing it is organic; there is considerable potential for harm to organic growers in the form of potentially reduced sales. However, the potential upside to this finding is that approximately 40% of the sample indicated organic product is more nutritious, even though the validity of this claim has not been scientifically documented (Dangour et al. 2009).

From Table 2, we see that perception and reality of the sample as a whole does not necessarily align as evidenced by the percentage of consumers that associated attributes with local and organic inaccurately. Given the common occurrence of inaccurate perceptions, we wanted to see if differences were present between U.S. and Canadian consumers and how consistent the misperceptions are. In examining this question we found key differences between U.S. and Canadian consumers, especially for local food perceptions (Table 2). For instance, Canadian consumers tend to be more likely to equate environmental benefits with local food more than

U.S. consumers. A higher percentage of Canadians perceive the characteristics of better for the environment, lower carbon footprint, and lower greenhouse emissions as associated with local compared with their U.S. counterparts. A potential reason for this finding is that specific environmental safeguards, such as Ontario's home use pesticide ban, could be influencing the perception about local agricultural production.

We also see that two characteristics that may or may not be true, more nutritious and longer shelf-life, are also perceived as being associated with local by a higher percentage of Canadian consumers compared to U.S. consumers. In contrast, U.S. consumers are more likely to perceive organic as being local, which as noted by Yue et al. (2009) is not always true. When examining differences between U.S. and Canadian organic perceptions, there was one production related difference. The perception around the use of natural fertilizer was significantly different between Canadian and U.S. consumers, whereby, Canadian consumers perceive this as an organic characteristic in slightly higher numbers than U.S. consumers.

Table 2. Percentage of Consumers Associating Various Characteristics with Local and Organic by Country.

	Local Perception				Organic Perception			
	Total	**U.S.**	**Canada**		**Total**	**U.S.**	**Canada**	
Number of observations	2,517	1,716	809		2,517	1,716	809	
Characteristics								
I do not know what local (organic) is	4%	4%	4%		3%	3%	3%	
Decreased miles to transport product	67%	65%	72%	***	12%	12%	14%	
Better for the environment	40%	37%	45%	***	53%	53%	53%	
Lower carbon footprint	35%	32%	41%	***	30%	30%	29%	
Lower greenhouse gas emissions	26%	23%	31%	***	24%	24%	24%	
Less pesticide residue on products	20%	21%	18%		51%	50%	52%	
Artificial fertilizer used	3%	3%	3%		4%	5%	4%	
Natural fertilizer used	21%	21%	21%		61%	60%	64%	*
No natural pesticide use	9%	10%	8%		25%	26%	24%	
No synthetic pesticide use	17%	17%	16%		67%	67%	66%	
Non genetically modified	22%	22%	23%		57%	56%	59%	
Products have a longer shelf life	23%	21%	26%	***	9%	9%	10%	
Better taste	44%	44%	44%		36%	35%	37%	
More nutritious	29%	28%	32%	*	40%	41%	38%	
Produced organically (locally) [1]	23%	25%	20%	***	17%	17%	18%	
Higher prices	21%	20%	23%	*	54%	53%	57%	**
Some other characteristic not listed	5%	5%	6%		0%	0%	0%	

[1]When examining local perception we are evaluating the percentage of consumers that perceive organic is a characteristic of local and vice versa.

Note. *,**,*** represents statistical difference between U.S. and Canadian consumers at the 0.1, 0.05, and 0.01 significance level.

With respect to consumers perceiving higher prices for local and organic, we find that a higher percentage of consumers believe higher prices are associated with organic than for local food. Furthermore, Canadian consumers perceive this to be the case in higher numbers than U.S.

consumers. For instance, a significantly higher percentage (23%) of Canadian consumers perceive local as having a higher price compared to U.S. consumers (20%). Comparatively, significantly more Canadian consumers perceive organic as having a higher price (57%) compared to U.S. consumers (53%). These findings are not without merit given organic products have been shown to have significant premiums associated with them (Lin, Smith, and Huang 2009).

Consumer Profiles: Local Perceptions

In examining local perceptions, we do not present or discuss all the characteristics listed in Table 2, but rather focus on specific characteristics.[1] Examining what is an accurate perception of local, "decreased miles to transport," we see that gender and age are significant for both U.S. and Canadian respondents (Table 3, see Appendix). For instance, a 10-year increase in age above the mean age results in an increased probability of 3.9% (for Canadian) and 3.8% (for U.S.) that decreased miles would be perceived as local. Canadian females were 10.1% more likely to associate decreased miles with local, while U.S. females were 10.3% more likely. However, Caucasians in the U.S. are 11% more likely to view decreased miles as local whereas Caucasians in Canada are no more likely than other races in Canada. Furthermore, consumers having heard of other environmental terms, had both an increased frequency of purchasing local and increased recycling play a role in perceiving decreased miles to transport as being local for both U.S. and Canadian respondents. Having heard of the term eco-friendly and sustainable increases the likelihood of perceiving decreased miles as local by about 30% and 20%, respectively. Furthermore, we see that increased frequency of purchasing local produce increases the likelihood of perceiving decreased miles to transport as a component of local. Finally, increased recycling has a positive impact on accurately perceiving decreased miles with local.

With regard to nutrition/taste characteristics, purchasing frequency of local and organic produce is the only variable that is consistently significant across countries and for both the "better taste" and "more nutritious" characteristics. In each case, purchasing more local and organic produce increases the probability that the respondent associates better taste and more nutritious with local. We do see similarities for variables across countries but that are not consistent between "better taste" and "more nutritious." For instance, older consumers are more likely to associate "better taste" with local, while age does not affect whether a respondent perceived "more nutritious" as a characteristic of local. This finding has practical implications for agribusiness retailers marketing local product in that older consumers are more likely to respond to messaging around "better taste" than messaging that focuses on the nutrition content of the local product.

We also see differences between U.S. and Canadian consumers. Increased income results in a decreased probability of perceiving a local product as "better tasting" compared to Canadian consumers. A $10,000 increase in the mean income (i.e. wealthier consumers) results in a 0.6% decrease in U.S. consumers perceiving local is better tasting, while income does not have an effect on Canadian consumer's perception of better taste. However, increasing Canadian

[1] Marginal effects for those characteristics listed in Table 2 not presented in the manuscript are available via the contact author.

consumer income by $10,000 from the mean would make them 0.8% less likely to perceive local as more nutritious where income changes for U.S. consumers would not effect this perception. Further, urban consumers in the U.S. are less likely than their suburban and rural counterparts to perceived local as better tasting, which is not the case with Canadian consumers. In contrast, females in Canada are more likely to perceive local as "more nutritious" compared to their U.S. counterparts.

With respect to a common claim of local being "better for environment," consumers purchasing increased amounts of local and organic are more likely to perceive this as being a characteristic of local. We also see that consumers that recycle more are more likely to believe this to be the case as well. However, older U.S. consumers are less likely to perceive local as better for the environment as are higher income U.S. consumers. Female Canadians are 3.8% more likely to have this perception compared with no difference for U.S. females. Having heard of the term sustainable increases the perception regarding environmental benefit, whereby having heard of the term eco-friendly only impacts U.S. consumers.

Examining Table 4 (see Appendix), we see that consumers perceiving local as having a higher price tend to be younger U.S. consumers. Income is only significant for U.S. consumers implying a higher income consumers are more likely (0.5% increase in the probability) to perceive local as higher priced. With respect to organic, we see that higher income Canadian consumers are less likely to associate organic with local. U.S. consumers that are younger, female, more educated, and non-Caucasian are more likely to associate organic with local. The consumer profile for U.S. consumers perceiving non-genetically modified organism (GMO) as being a part of local product is similar to that of those perceiving organic is local. For instance, younger, higher educated U.S. consumers are more likely to perceive non-GMO as local.

When examining specific environmental perceptions across all characteristics and countries, a specific consumer profile emerges. Young consumers that more frequently purchase local and organic produce are more likely to attribute environmental characteristics to local (Table 5, see Appendix). However, there are differences between characteristics and countries. Canadian females are more likely to perceive lower carbon footprint as local, while U.S. females are more likely to perceive less pesticide residue as a characteristic of local.

However, key differences emerge across characteristic and country. Notably, we can identify the consumer profile that misperceives no synthetic pesticide as local. For Canadian consumers, lower income, more adults in the household, more educated consumers that both purchase increasing amounts of local and organic and recycle more perceive local product as not having any synthetic pesticide applied to it. U.S. consumers that are younger, female, higher educated and non-Caucasian are more likely to share this belief. Interestingly, for U.S. consumers increasing purchases of local product does not affect this perception. From these results it is clear that the consumer profiles associated with misperceptions are not shared between countries.

Consumer Profiles: Organic Perception

As noted above, organic is more heavily regulated than local, especially in regard to production practices. This being said, a key characteristic of organic production is the lack of use of synthetic pesticides within production. This message of pesticide free is broadly emphasized throughout marketing material in the U.S. and Canada. However, only 2 in 3 consumers associate no synthetic pesticides with organic (Table 2). The reasons for this is unknown, especially given there are similar organic mandates within the U.S. and Canada for no synthetic pesticide use.

Using demographics and purchasing behaviors we can attempt to understand who has accurate perceptions. Caucasian females in the U.S. and Canada tend to be more likely to perceive no synthetic pesticide use as a characteristic of organic (Table 6, see Appendix). Of interest is the lack of significance for the local and organic purchasing variables. As local and organic produce purchasing increases there is no significant (except for U.S. local purchasing) differences for those purchasing more/less of local/organic produce. Also of interest is that increased recycling and having heard of the term sustainable is associated with the correct perception of organic as having no synthetic pesticide used.

In regards to the nutrition/taste characteristics (i.e. better taste and more nutrition), we see some variables show significant differences between the U.S. and Canada. Younger female consumers in both the U.S. and Canada are more likely to perceive organic as more nutritious, while more educated U.S. consumers are more likely to perceive organic as more nutritious. We also see that higher educated U.S. consumers are more likely to perceive organic as better tasting. Purchasing increased amounts of organic product also has a significant impact on a respondent perceiving organic as better tasting and more nutritious. This is not unexpected as this perception is most likely why respondents purchase organic product. However, unlike the local model results in Table 3 (see Appendix), purchasing more local does not have a significant impact on a respondent perceiving organic as better tasting or more nutritious. This seems to indicate that organic buyers see a nutrition/taste benefit in local and organic, while local buyers only see a nutrition/taste benefit in local.

As with the local results, there are some consumers who perceive organic as being higher priced (Table 7, see Appendix). Both U.S. and Canadian females and households with fewer adults are more likely to perceive organic as higher priced. With respect to other demographics there are both positive and negative signs for agribusiness firms marketing organic products. As a positive for firms providing organic product, Canadian households with increasing amounts of children are less likely to perceive organic as having a higher price. This seems to indicate that households with children may see organic as worth the investment for the perceived safety gain. However, Canadian households with higher incomes are more likely to perceive organic as higher priced. Given these households potentially have more disposable income to spend, this higher priced image could be problematic especially given our results that higher income U.S. consumers are less likely to perceive organic as better tasting and better for the environment.

As noted in Table 2, local and organic are being characterized together by 17%-25% of consumers. Efforts to change this misperception are routed in understanding the demographics and purchasing behaviors associated with each. Our findings indicate distinct consumer profiles emerging for each country. Canadian females living outside an urban location are more prone to characterize local as organic, whereas older, lower income, non-Caucasian consumers that live in larger households are more likely to perceive local as organic. Firms attempting to correct the misperception that local and organic are the same should utilize the above profiles to effectively and efficiently target the groups harboring these misperceptions.

In regards to the environmental characteristics, we see consistent profiles associated with commonly accepted characteristics (Table 8, see Appendix). For instance, higher educated consumers and consumers that purchase more organic produce are more likely to associate various environmental characteristics with organic. However, we do see differences emerge, especially for the misperception that organic implies decreased miles to transport. Older male U.S. consumers with lower incomes are more likely to have this misperception, while higher educated but lower income Canadian consumers are more likely to perceive decreased miles to transport with organic. For the other environmental characteristics we see that gender, education, and income play a role for several of the characteristics but in different ways. For instance, higher income U.S. consumers are more likely to perceive organic as having less pesticide residue, however, lower income U.S. consumers are more likely to associate lower carbon footprint with organic.

Discussion and Conclusion

The results of this study provide critical insights into the nature of local and organic perceptions and misperceptions, especially in regards to differences between U.S. and Canadian consumers, from a relatively large (n=2511) sample. Consistent with previous studies, notably Campbell, Mhlanga, and Lesschaeve (2013), we find that many consumers have accurate perceptions of local and organic for characteristics that are heavily touted, such as no synthetic pesticide use for organic and decreased miles to transport for local. However, we also see that many consumers have inaccurate perceptions of both local and organic terminology. Consumers' inaccurate perceptions of (especially) local production indicate broader concern in terms of understanding its long-term economic impacts, regardless of organic or conventional practices. More research needs to be conducted to investigate the relationship between consumer preferences, demand for local production, and regional economic growth, and whether or not benefits of local production will offset lost economic gains from trade.

A closer investigation of consumer profiles showed noticeable differences between U.S. and Canadian consumers with respect to certain characteristics. These differences are not well understood and deserve more in-depth study, especially given the flow of products between these countries. We also see key perception differences between males and females and Caucasian versus other races. Purchasing behaviors also play a key role in a consumer's perception of local and organic.

Marketers need to be aware of the terms for which consumers have accurate perceptions and develop marketing messages to capitalize on those perceptions. Conversely, we recommend avoiding the use of words or messaging which have confusing, inaccurate, or ambiguous meaning to consumers. Some may theorize that above-average returns could be extracted by firms because of these misperceptions, as was the case early on in the life cycle of organic fruits and vegetables (Kremen et al. 2012). However, as standards were developed and consumers more fully understood the definitional aspects of the term "organic" then above-average returns dissipated and were accrued mainly by producers who educated as a part of their marketing efforts. The authors hypothesize this being true of the term "local" as well.

Perhaps an element of education could be added throughout the marketing process to help to aid plant producers clarify and correct terminology for all consumers. Marketers may consider being more precise in their terminology if an accurate perception of their production systems is desired. Given the ambiguity in meaning for the terms local and organic, adding specific semantics to underscore the specific production practices (e.g. no synthetic pesticides used) may further emphasize the importance of the organic attribute. Still, a positive aura may be derived from the positive ambiguity either local or organic have, serving only to enhance the desirability of the product from the ambiguous term. The desirability resulting from such positive perceptions may either translate into price premiums if consumers view this as a resonating point of differentiation or may sway their purchasing conditions at current price levels given that all other attributes among competing products are similar.

Acknowledgements

The authors gratefully acknowledge funding from the USDA-Federal State Marketing Improvement Program (FSMIP). We also would like to thank Vineland Research and Innovation Centre (Vineland Station, Ontario) for their help and support of this work.

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Appendix

Table 3. Marginal effects associated with the binary logit models for the accurate, nutrition/taste, general environment characteristic of local.

	Accurate: Decreased Miles to Transport		Nutrition/Taste: Better Taste		Nutrition/Taste: More Nutritious		General Environment: Better for Environment	
	Canada	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**
Demographics [1]								
Age [2]	0.039 ***	0.038 ***	0.038 ***	0.034 ***	0.020	0.005	0.014	-0.028 ***
Number adults in household	-0.041 ***	-0.023 **	-0.012	0.017	0.000	0.014	0.017	0.009
Number children in household	-0.014	0.014	-0.015	-0.002	-0.005	0.008	0.021	0.005
Income [3]	-0.000	-0.000	-0.006	-0.006 *	-0.008 *	-0.004	0.000	-0.006 *
Gender (1=male)	-0.101 ***	-0.103 ***	-0.008	-0.023	-0.077 **	-0.006	0.038 *	-0.033
Area type								
Suburban Education	0.052	0.052	0.070	0.075 **	0.031	0.017	0.043	-0.048
Rural Education	0.036	0.060	0.030	0.167 ***	0.020	0.027	0.053	0.008
High school 4 years	-0.113 *	-0.032	0.047	0.009	0.009	0.052	0.058	0.020
Bachelor's degree	-0.019	0.066 **	-0.007	0.066 **	0.051	0.021	0.047	0.037
Bachelor's degree >	-0.072	0.018	0.076	-0.035	0.079	-0.055	0.067	-0.011
Race (1=Caucasian)	0.061	0.110 ***	0.055	-0.037	-0.016	-0.013	0.059	-0.002
Heard of term								
Eco-friendly (1=yes)	0.295 ***	0.299 ***	0.267 ***	0.147 ***	0.098	0.112 ***	0.104	0.100 **
Sustainable (1=yes)	0.196 ***	0.203 ***	-0.040	-0.048	0.034	0.024	0.048 ***	0.075 ***
Frequency of purchasing when available [4]								
Local produce	0.046 **	0.038 **	0.103 ***	0.082 ***	0.078 ***	0.027 *	0.026 **	0.035 **
Organic produce	-0.024	-0.032 **	0.050 **	0.052 ***	0.091 ***	0.070 ***	0.022 ***	0.063 ***
Recycling index [5]	0.068 ***	0.041 ***	0.013	-0.002	0.030	-0.010	0.027 *	0.054 ***
Log pseudo likelihood	-400.8	-968.1	-510.1	-1101	-458.6	-971.5	-510.2	-1060.5
Wald chi2	132.9	216.1	68.7	124.0	72.7	79.5	75.6	108.9
Pseudo R2	0.157	0.126	0.074	0.061	0.085	0.043	0.077	0.058
Sensitivity	0.729	0.708	0.664	0.626	0.665	0.633	0.642	0.645
Specificity	0.643	0.603	0.597	0.622	0.627	0.574	0.591	0.586
Correctly Classified	0.705	0.671	0.626	0.624	0.639	0.591	0.615	0.608

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by $10,000 changing the interpretation to a $10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

Table 4. Marginal effects associated with the binary logit models for the price and trending issues characteristic of local.

	Price		Trending Issues			
	Higher Priced		Organic		Non-Genetically Modified Organism	
	Canada	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**
Demographics [1]						
Age [2]	-0.013	-0.040 ***	-0.012	-0.029 ***	-0.002	-0.023 ***
Number adults in household	0.012	-0.009	-0.001	0.006	0.004	-0.002
Number children in household	-0.057 ***	-0.007	0.005	-0.010	-0.009	-0.011
Income [3]	-0.004	0.005 **	-0.010 **	-0.000	-0.005	-0.003
Gender (1=male)	-0.072 **	-0.023	-0.012	-0.042 *	-0.052 *	-0.021
Live in suburban area	-0.004	-0.014	0.042	0.046 *	0.004	-0.009
Live in rural area	-0.098 ***	-0.017	0.055	0.056	0.004	0.029
Education						
High school - 4 year degree	-0.006	-0.029	0.018	0.067 *	0.011	0.096 ***
Bachelor's degree	0.050	0.004	-0.007	0.055 **	0.015	0.066 **
Bachelor's degree >	0.174 **	0.017	0.089	0.041	0.070	0.010
Race (1=Caucasian)	0.042	0.032	-0.017	-0.066 **	0.015	0.029
Heard of term						
Eco-friendly (1=yes)	0.058	0.035	-0.002	0.095 ***	0.064	0.074 **
Sustainable (1=yes)	0.070 **	0.045 **	-0.055	-0.006	-0.019	0.046 **
Frequency of purchasing when available [4]						
Local produce	-0.066 ***	-0.046 ***	0.026	-0.003	0.059 ***	0.006
Organic produce	-0.034 **	0.017	0.111 ***	0.115 ***	0.050 ***	0.064 ***
Recycling index [5]	0.025	0.020 *	0.023	-0.003	0.056 **	0.034 ***
Log pseudo likelihood	-407.2	-825.1	-353.0	-880.0	-404.5	-839.1
Wald chi2	47.06	56.33	84.07	161.71	40.2	102.38
Prob > chi2	0.0001	0.000	0.000	0.000	0.0007	0.000
Pseudo R2	0.068	0.037	0.117	0.089	0.059	0.063
Sensitivity	0.644	0.6093	0.673	0.6566	0.6593	0.6532
Specificity	0.626	0.5735	0.6568	0.6349	0.5942	0.6114
Correctly Classified	0.630	0.5807	0.66	0.6404	0.609	0.6205

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by \$10,000 changing the interpretation to a \$10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

Table 5. Marginal effects associated with the binary logit models for the environmental characteristic of local.

	Lower Carbon Footprint		Lower Greenhouse Emissions		No Synthetic Pesticide Used		Less Pesticide Residue	
	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
Demographics [1]								
Age [2]	-0.011	-0.025 ***	-0.022 *	-0.020 ***	0.005	-0.017 **	0.007	-0.010
Number adults in household	-0.027	-0.023 **	-0.006	0.006	0.020 *	0.000	-0.015	0.007
Number children in household	-0.060 ***	0.000	-0.024	0.004	0.000	0.001	0.011	0.001
Income [3]	0.003	0.001	-0.003	-0.002	-0.013 ***	0.001	-0.006	0.000
Gender (1=male)	-0.094 **	-0.022	-0.027	0.011	-0.013	-0.057 ***	-0.021	-0.034 *
Live in suburban area	-0.022	-0.064 **	-0.011	-0.073 ***	-0.001	-0.015	-0.002	0.011
Live in rural area	-0.038	-0.040	-0.031	-0.045	0.043	0.026	0.017	0.014
Education								
High school - 4 year	-0.135 **	-0.019	-0.042	-0.017	0.042	0.055 *	0.023	0.111 ***
Bachelor's degree	-0.042	0.003	-0.054	-0.027	0.062 *	0.044 *	0.020	0.092 ***
Bachelor's degree >	-0.073	-0.012	-0.021	-0.046	0.121 *	-0.025	0.032	0.010
Race (1=Caucasian)	-0.008	0.097 ***	0.058	0.047 **	-0.043	-0.058 **	-0.035	-0.014
Heard of term								
Eco-friendly (1=yes)	0.072	0.131 ***	0.220 ***	0.088 **	0.039	0.083 ***	0.088 *	0.085 ***
Sustainable (1=yes)	0.212 ***	0.133 ***	0.089 **	0.098 ***	-0.023	-0.007	-0.059	-0.032
Frequency of purchasing when available [4]								
Local produce	0.037	-0.009	0.020	0.013	0.032 **	-0.001	0.059 ***	0.006
Organic produce	0.078 ***	0.048 ***	0.074 ***	0.038 ***	0.059 ***	0.057 ***	0.062 ***	0.047 ***
Recycling index [5]	0.067 **	0.048 ***	0.017	0.035 ***	0.041 **	0.010	0.005	0.026 **
Log pseudo likelihood	-486.5	-1014.0	-469.9	-871.1	-319.2	-741.8	-354.0	-838.7
Wald chi2	86.2	105.8	48.0	95.5	61.1	81.9	61.0	66.4
Prob. > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.103	0.059	0.058	0.056	0.098	0.059	0.078	0.043
Sensitivity	0.678	0.670	0.665	0.645	0.682	0.628	0.642	0.647
Specificity	0.606	0.564	0.556	0.570	0.656	0.593	0.637	0.588
Correctly Classified	0.635	0.598	0.590	0.587	0.660	0.599	0.638	0.600

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by $10,000 changing the interpretation to a $10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

Table 6. Marginal effects associated with the binary logit models for the accurate, nutrition/taste, and general environment characteristic of organic.

	Accurate No Synthetic Pesticides Used		Nutrition/Taste More Nutritious				General Environment Better for Environment	
	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.
Demographics [1]								
Age [2]	0.016	0.014	0.006	-0.004	-0.024 *	-0.028 ***	-0.014	-0.004
Number adults in household	-0.045 ***	-0.028 ***	-0.003	0.016	-0.029 *	0.011	0.002	0.003
Number children in household	-0.025	0.008	0.004	0.009	-0.020	-0.016	-0.025	-0.004
Income [3]	0.004	0.002	-0.007	-0.006 **	-0.001	-0.004	-0.001	-0.011 ***
Gender (1=male)	-0.085 **	-0.118 ***	-0.004	0.006	-0.091 **	-0.106 ***	-0.091 **	-0.086 ***
Area type	-0.038	0.029	0.005	-0.028	-0.001	-0.058 *	0.026	-0.034
Suburban	-0.055	0.050	0.027	-0.022	0.022	-0.034	0.014	0.034
Rural								
Education	-0.048	0.006	0.017	0.072 *	0.056	0.126 ***	0.044	0.045
High school - 4 year	-0.028	0.029	-0.016	0.076 **	0.015	0.104 ***	-0.017	0.082 **
Bachelor's degree	-0.163 **	-0.037	0.073	-0.040	-0.035	-0.003	-0.012	0.017
Bachelor's degree >	0.137 **	0.148 ***	0.068	-0.055 *	-0.025	-0.027	0.045	0.010
Race (1=Caucasian)								
Heard of term	0.143	0.298 ***	0.054	0.102 **	0.237 ***	0.178 ***	0.116	0.279 ***
Eco-friendly (1=yes)	0.180 ***	0.167 ***	-0.134 ***	0.011	-0.016	0.003	0.113 **	0.063 **
Sustainable (1=yes)	0.016	0.014	0.006	-0.004	-0.024 *	-0.028 ***	-0.014	-0.004
Frequency of purchasing when available [4]								
Local produce	0.017	0.037 **	0.006	0.020	-0.004	-0.009	0.030	0.009
Organic produce	0.022	0.002	0.225 ***	0.147 ***	0.180 ***	0.143 ***	0.127 ***	0.118 ***
Recycling index [5]	0.104 ***	0.043 ***	0.064 **	0.000	0.070 ***	0.008	0.026	0.037 ***
Logpseudo likelihood	-454.5	-958.8	-452.6	-1008.0	-471.9	-1056.6	-512.5	-1079.2
Wald chi2	104.6	205.7	112.9	159.7	101.2	170.9	78.5	167.1
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.118	0.119	0.143	0.092	0.116	0.087	0.078	0.087
Sensitivity	0.718	0.717	0.718	0.679	0.692	0.671	0.646	0.689
Specificity	0.608	0.590	0.643	0.631	0.629	0.631	0.623	0.596
Correctly Classified	0.680	0.674	0.670	0.648	0.653	0.647	0.636	0.645

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by $10,000 changing the interpretation to a $10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

Table 7. Marginal effects associated with the binary logit models for the price and trending issues characteristic of organic.

	Price				Trending Issues							
	Higher Priced				Local				Non-Genetically Modified Organism			
	Canada		**U.S.**		**Canada**		**U.S.**		**Canada**		**U.S.**	
Demographics[1]												
Age[2]	-0.005		-0.012		0.012		0.016	**	-0.000		-0.021	**
Number adults in household	-0.040	**	-0.027	***	0.005		0.017	***	-0.008		-0.030	***
Number children in household	-0.048	**	-0.010		0.003		0.016	**	-0.050	**	0.015	
Income[3]	0.012	**	-0.003		-0.014	***	-0.006	**	0.001		0.003	
Gender (1=male)	-0.115	***	-0.110	***	0.075	***	0.020		-0.066	*	-0.062	**
Live in suburban area	-0.067		-0.018		0.063	**	0.002		0.012		-0.010	
Live in rural area	-0.080		-0.028		0.093	**	0.015		0.063		0.003	
Education												
High school - 4 year degree	0.052		-0.103	***	0.010		0.020		-0.056		0.011	
Bachelor's degree	0.030		-0.005		0.006		0.007		0.022		0.071	**
Bachelor's degree >	-0.004		-0.035		0.076		-0.020		0.003		-0.020	
Race (1=Caucasian)	0.053		0.076	**	0.018		-0.060	**	0.095		0.066	**
Heard of term												
Eco-friendly (1=yes)	0.085		0.170	***	0.061		0.068	**	0.197	**	0.324	***
Sustainable (1=yes)	0.188	***	0.083	***	-0.034		0.000		0.093	**	0.185	***
Frequency of purchasing when available[4]												
Local produce	0.008		0.035	**	0.004		-0.006		0.005		0.005	
Organic produce	-0.078	***	-0.068	***	0.086	***	0.076	***	0.067	***	0.049	***
Recycling index[5]	0.055	**	0.031	**	0.032	*	-0.005		0.090	***	0.041	***
Log pseudo likelihood	-509.0		-1127.1		-333.9		-721.5		-505.5		-1070.4	
Wald chi2	66.7		98.5		83.2		94.7		74.9		163.7	
Prob. > chi2	0.000		0.000		0.000		0.000		0.000			
Sensitivity	0.666		0.644		0.6875		0.6319		0.6631		0.7274	
Specificity	0.615		0.5691		0.6742		0.6287		0.5512		0.5501	
Correctly Classified	0.644		0.6088		0.6766		0.6292		0.6169		0.6497	

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by $10,000 changing the interpretation to a $10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

Table 8. Marginal effects associated with the binary logit models for the environmental characteristic of local.

	Lower Carbon Footprint		Lower Greenhouse Emissions		No Synthetic Pesticide Used		Less Pesticide Residue	
	Canada	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**	**Canada**	**U.S.**
Demographics [1]								
Age [2]	0.000	-0.006	0.004	-0.019 **	-0.007	0.003	0.010	0.010 *
Number adults in household	0.009	-0.010	0.017	-0.003	0.001	0.000	0.013	0.009
Number children in household	-0.010	0.007	-0.021	0.005	0.007	0.005	-0.018	0.013 *
Income [3]	-0.004	-0.006 **	0.000	-0.003	0.002	-0.001	-0.010 ***	-0.004 **
Gender (1=male)	-0.028	-0.039 *	-0.045	-0.070 ***	0.003	0.008	0.022	0.032 **
Live in suburban area	0.020	-0.002	-0.024	-0.031	0.005	-0.003	0.010	-0.012
Live in rural area	0.026	-0.048	-0.013	-0.021	0.018	0.004	0.037	-0.019
Education								
High school - 4 years	-0.013	0.077 **	0.029	0.065 *	-0.001	0.025	0.076 *	0.019
Bachelor's degree	-0.011	0.104 ***	-0.019	0.082 ***	0.007	0.023 *	0.072 **	0.014
Bachelor's degree >	0.007	-0.048	-0.058	-0.021	0.016	-0.008	0.067	-0.030
Race (1=Caucasian)	0.039	-0.020	0.059	0.002	-0.001	-0.013	-0.014	-0.005
Heard of term								
Eco-friendly (1=yes)	0.046	0.160 ***	0.131 **	0.123 ***	0.014	-0.034	0.004	0.048 **
Sustainable (1=yes)	-0.042	0.106 ***	-0.050	0.035	-0.063 ***	0.005	-0.010	-0.006
Frequency of purchasing when available [4]								
Local produce	0.028	-0.003	0.017	0.017	0.009	-0.003	0.007	0.007
Organic produce	0.096 ***	0.055 ***	0.095 ***	0.041 ***	0.007	0.011 **	0.068 ***	0.046 ***
Recycling index [5]	0.045 *	0.027 **	0.033	0.025 **	0.000	0.003	0.024	0.003
Log pseudo likelihood	-456.1	-985.7	-414.8	-888.3	-129.6	-308.3	-281.7	-573.0
Wald chi2	49.3	87.1	59.8	78.2	29.9	22.0	76.0	67.7
Prob. > chi2	0.000	0.000	0.000	0.000	0.018	0.1423	0.000	0.000
Pseudo R2	0.054	0.056	0.071	0.050	0.080	0.028	0.122	0.062
Specificity	0.604	0.577	0.604	0.575	*0.669*	0.591	0.674	0.619
Correctly Classified	0.610	0.606	0.607	0.591	*0.668*	0.590	0.683	0.619

[1] The base categories are gender=female, live in urban area, education=less than high school, race=other, heard of…=no.
[2] The marginal effect for the age variable is multiplied by 10 years changing the interpretation to a 10 year increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[3] The marginal effect for the income variable is multiplied by $10,000 changing the interpretation to a $10,000 increase/decrease in the mean results in the probability change in perceiving the characteristic as local.
[4] Frequency of purchasing was measured by a scale where 1=never, 2=seldom, 3=sometimes, 4=most times, and 5=always.
[5] Respondents were asked how often they recycle glass, cardboard, and aluminum. The rating scale used was 1=do not purchase, 2=never, 3=sometimes, 4=usually, and 5=always. Do not purchase and never were then combined. The index was created by averaging the ratings for recycling of glass, cardboard, and aluminum.
Note. *,**,*** represents statistical difference at the 0.1, 0.05, and 0.01 significance level.

International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Investment Potential for New Sugarcane Plants in Brazil Based on Assessment of Operational Efficiency

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Abstract

The aim of this study is to elaborate on a map of agricultural potential for investing in new sugarcane plants in Brazil. A study of operational efficiency was conducted using Data Envelopment Analysis (DEA) in which it was possible to identify in 2009 the most efficient plants out of a universe of 355. Quantitative analysis suggests a tendency for efficient plants to be large and located in the state of São Paulo. Operational efficiency was proven to depend on the variables of size and location in which the state of São Paulo has a greater concentration of favorable edaphoclimatic conditions for extracting sugarcane with higher sucrose content. An analysis of agricultural potential in the Brazilian territory suggests the installation of new energy plants in regions that present favorable edaphoclimatic conditions and greater efficiency indexes. The states that were proven favorable, in terms of operational efficiency, are Alagoas, Pernambuco and certain regions of Minas Gerais, Paraná and Mato Grosso do Sul.

Keywords: sugarcane; agribusiness; data envelopment analysis (DEA); operational efficiency

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Introduction

This study addresses the operational efficiency of sugarcane and ethanol production plants in Brazil during the 2008/2009 harvest using the Data Envelopment Analysis (DEA) technique; case studies are subsequently presented with the aim of achieving an in-depth understanding of the variables that influence this process.

According to The World Bank (2012), Brazil has the seventh largest economy in the world, with a GDP of US$ 2.253 trillion. Brazil is the world leader in coffee, sugarcane and orange production. Its main agricultural products are soybean, meat, sugar/ethanol, coffee, oranges, corn, cassava and tobacco (Pereira, Teixeira and Raszap-Skorbiansky, 2010). Among the crops produced in Brazil today, the sugarcane agroindustry is of greatest importance to the country. The Brazilian Institute of Geography and Statistics – IBGE (2011) states that the 2009/2010 sugarcane harvest represented nearly 15% of Brazil`s total planted acreage. According to Torquato, Martins and Ramos (2009), the factors that drove the growth of sugarcane production in Brazil were crop expansion into new regions of Brazil in conjunction with growing demand and "environmental issues, such as the emission of pollutants caused by fossil fuels," which are currently high on society's agenda. Corroborating statistics from the Sugarcane Industry Union – UNICA (2011) back up this claim, by indicating that sugarcane processing between the 2001/2002 and the 2008/2009 harvests increased by 94%, whereas sugar and ethanol production over the same period grew by 62% and 138%, respectively. Sugar and ethanol production in Brazil is a key component of the country`s rural and energy development strategy (Martinelli et al., 2011).

According to Bragato et al. (2008), Brazil`s sugar and alcohol sector drives development with a significant social dimension and is the foundation of the country`s economic sustainability. In support of the above statement, Torquato, Martins and Ramos (2009) point out that production facilities in the sugar and alcohol sectors must seek to achieve greater efficiency in the use of resources employed in production, by adapting to a new production model, which takes into account growing competition and optimization of productivity. In Brazil, the state of São Paulo is of great importance to the sugarcane agroindustry. Today, the state of São Paulo is responsible for half the acreage occupied by Brazil`s sugarcane crop and is responsible for 60% of all sugarcane available for processing. This proves the importance of São Paulo to the sugarcane crop (Martinelli et al., 2011).

Besides the importance of the sugarcane agroindustry to the country, there are opportunities for growth and for greater investment. According to UNICA (2011), in order to manage and balance sector production and demand, private enterprise has tried to create market instruments, such as futures operations, and to develop new opportunities for sugar and ethanol by eliminating protectionist barriers and striving to transform ethanol into an environmental "commodity." Used in the production of sugar and ethanol fuel, sugarcane has been the object of study as a possible solution for today's environmental issues, as mentioned above. Hence, it is important to study the efficiency of plants that process the crop yielding sugar and ethanol and to investigate possible alternatives in order to improve production processes based on decisions aimed at achieving greater efficiency. It also becomes important to undertake studies that explore the variables influencing efficiency with the aim of supporting the decision-making process as it pertains to the choice of sites and technologies for new sugar/ethanol plants.

Considering the importance of this theme, the present study aims to develop an agricultural potential map for investments in new sugar/ethanol plants in Brazil, taking into account their operational efficiency.

Literature Review

According to Goldemberg and Guardabassi (2009), measures are in progress to meet the growing demand for ethanol fuel in Brazil. According to Dias et al (2011), an increase in the planted acreage will be necessary, as will improvements in sugarcane agriculture. Such improvements will be necessary in order to make possible the production of a greater quantity of ethanol per hectare, as well as the development of new technologies and improvements in existing processes, thereby permitting a greater quantity of ethanol to be obtained per ton of sugarcane. It thus becomes necessary to describe the sugar and ethanol production process.

According to Morandin et al. (2011), the conversion of sugarcane into sugar or ethanol consists of a series of physical and chemical processes that take place in seven basic sub-systems. Portions of the production process are common to both sugar and ethanol. The common areas include the planting, cultivation and harvesting of sugarcane, as well as the weighing, sampling and delivery of sugarcane to the production line. After that, the broth is extracted, which represents the raw material for the production of sugar and ethanol. In order to produce sugar, the processes of purification, evaporation, crystallization and centrifugation are implemented through the final production of sugar. Production of ethanol is initiated by fermentation, and then distillation followed by dehydration, ultimately arriving at the final product, ethanol.

Figure 1 shows a simplified flowchart for the basic sugar and ethanol production processes, in which the operations are the same up to the sugarcane broth extraction phase; the extract is later sent to the sugar production process or the ethanol production process. The processes enclosed in dashed lines will be described because of their importance to the results of the present research.

After examining the production process in sugarcane plants, a literature review of some important technologies and processes from the operational efficiency perspective also becomes relevant. According to Romão Junior (2009), chopped sugarcane, from mechanized harvesting, has more surface area to attract impurities. Thus, if the plant washes the chopped sugarcane with water, sugar loss will be around 5%, making this approach unfeasible.

The Sugarcane Technology Center (CTC), in partnership with the Technological Institute for Aeronautics (ITA), developed a technology for dry cleaning sugarcane, which functions by means of a ventilation process capable of eliminating the main impurities present in sugarcane harvested from the field. The sugarcane dry cleaningsystem (SLCS) is an alternative to systems in which sugarcane is washed with water. The straw (plant impurities) and most of the sand and dirt (mineral impurities) are removed. There is no sucrose loss, permitting the process to be used for whole or chopped sugarcane, with return of impurities to the field.

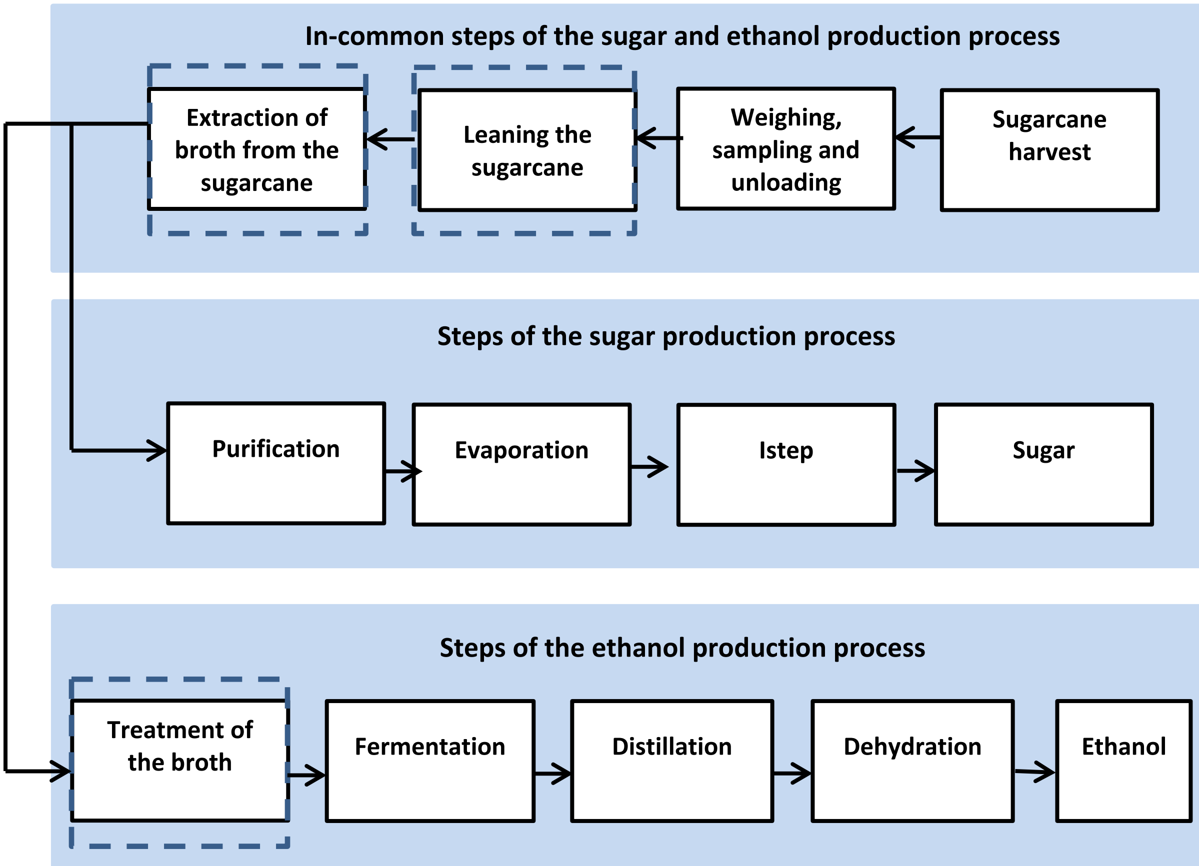

Figure 1. Flow diagram for the basic sugar and ethanol production process
Source. Adapted by Krajnc and Gravic (2009)

Another important step in the sugar and ethanol production process is broth extraction. The frequently used technologies in this process are the diffuser and the grinder. In this step, the plant seeks to extract as much broth as possible with as few impurities as possible. Grinding is a physical extraction process, in which separation occurs as a result of mechanical pressure on the sugar cane during milling. Diffusion requires two steps: separation by reverse osmosis and leaching.

According to Nazato et al. (2011), in the extraction process using the diffuser, installation and maintenance are more economical. The broth is richer in sucrose and partially clarified and has a favorable energy balance. With the grinder, there is no need for high quality raw material. Adaptation to the period between harvests, when sugarcane is scarce, is readily achieved. The grinder leaves an ideal residue for burning due to its low moisture content and the grinding equipment can be expanded, permitting an increase in the quantity of sugarcane ground. Therefore, both technologies have their advantages.

Whereas the diffuser is able to extract between 97.5% and 98.5% of the broth and shows loss of quality when the raw material has low fiber content, the grinder is able to extract 96.5% to 97.5% of the broth and does not demonstrate any sort of extraction difficulty related to raw material quality (Nazato et al. 2011).

Treatment of the broth is another step in the process of broth fermentation or distillation, and is important from the perspective of the equipment used in the production process that allows for greater operational efficiency in the production of ethanol. Use of a broth treatment filter can guarantee greater operational efficiency through preservation of nutrients, vitamins, sugars and phosphates, and mineral salts, which are necessary for yeast metabolism, as well as reduction in contaminants through the elimination of impurities, which reduce efficiency of the machinery during production (Agência de Informação Embrapa 2012). In order to recover the sugar content of the sludge, it is necessary to proceed with the filtration process, that is, separation of the filtered broth from the residue retained by the filter. The broth returns to the production process and the cake, basically comprised of residue removed during decantation, is used in the fields. Therefore, the filter is able to retain impurities contained in the broth with low loss of sucrose content. The capacity to retain solids suspended in the liquid extracted from sugarcane increases from 57%, in the traditional system, to 93% using the filter (REDETEC 2012).

Sugarcane's Edaphoclimatic Aspects

Cesar et al. (1987) state that there are several factors that interfere in sugarcane production and maturation, such as edaphoclimatic interaction, crop management and the sugarcane variety chosen. The aforementioned factors are important to this study because they interfere with sugar and ethanol production. According to Lepsch (1987), knowledge of each soil's characteristics, the so-called edaphic factors, is important in judging the soil's potential productivity.

The initial concept of latosol considered soils whose characteristics were related to intense weathering and leaching and were responsible for low clay activity. Latosols are frequently used with annual crops, perennial crops, pastures and reforestation and are normally located on flat to gently undulating reliefs with declivities rarely greater than 7%, which facilitated the mechanization process. Despite the high potential for agriculture, a portion of the acreage must be set aside as a reserve to protect the environment's biodiversity (Agência de Informação Embrapa 2012).

In loamy soils, according to the Agência de Informação Embrapa (2012), a great deal of diversity is observed in properties relevant to fertility and agricultural use (variable nutrient content, texture, depth, presence or absence of gravel, stones, occurrence in different positions on the landscape). When fertility is high and stones are sparse, the soil is well suited for agriculture. Cambissol is a soil that is poorly developed. Its main characteristics are low depth and high gravel content. Also according to the Agência de Informação Embrapa (2012), purple soil includes soils of great importance to agriculture and with high production potential.

Corroborating this information, Ker (1997) states that purple latosol, commonly called purple soil, has great agricultural potential and is frequently found in the state of São Paulo. According to Delgado et al. (2012), the study of cultivated areas is a fundamental source of information in agricultural and territorial planning, in relation to economic, agrarian, environmental and social issues.

According to Netafim's Agriculture Department (2012), the quality of sugarcane broth is deeply influenced by prevailing climatic conditions during the various sub-periods of crop growth.

Thus, a favorable climate for growing sugarcane may be characterized as a long, hot season with rainfall between 1100 and 1500 mm, showing good distribution - especially, with the highest incidence during the growth months - as well as a reasonably dry and sunny season. Figure 2 shows the locations of Brazil's sugarcane industry.

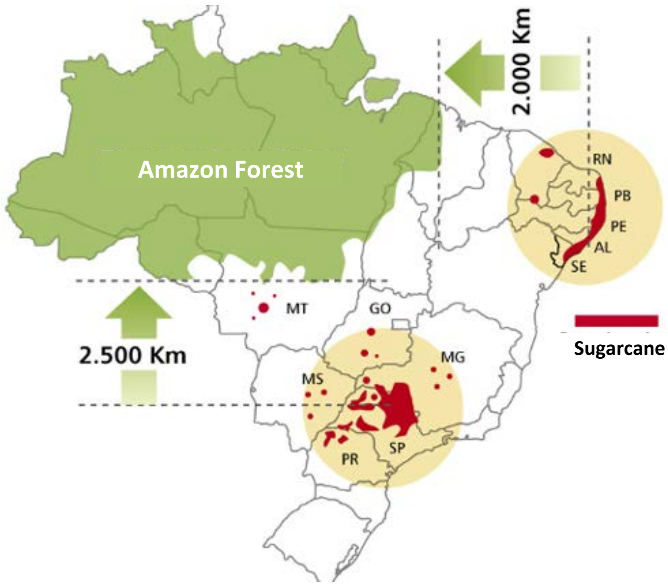

Figure 2. Sugarcane industry in Brazil
Source. UNICA (2011)

Chart 1 provides a summary of the main types of soil and climate in Brazilian territory in the sugarcane producing states.

Chart 1. Classification of edaphoclimatic factors in certain states in Brazil

State	Edaphoclimatic Conditions	
	Soil	*Climate*
São Paulo	Predominantly latosol, podzol and purple latosol.	Predominantly tropical
Minas Gerais	Predominantly latosol, podzol and purple latosol. Cambisol, lithic	Tropical
Paraná	Predominantly Cambisol and lithic Latosol, podzol and purple latosol.	Predominantly wet sub-tropical
Mato Grosso do Sul	Predominantly alluvial hydromorphic quartz sands.	Predominantly tropical
Goiás	Predominantly latosol, podzol and purple latosol.Cambisol, lithic	Tropical
Mato Grosso	Predominantly alluvial hydromorphic quartz sands. Leached soils under the forest.	Tropical and wet equatorial.
Alagoas	Predominantly non-calcic brown.Latosol, podzol.	Predominantly tropical.Tropical, semi-arid.
Pernambuco	Predominantly non-calcic brown.Latosol, podzol.	Predominantly tropical, semi-arid.Tropical

It is estimated that the sugarcane crop occupies 8 million hectares of land in Brazil, distributed in a heterogeneous manner over several states, with 60% in the state of São Paulo (Novaes et al. 2011).

Conceptual Framework

The Data Envelopment Analysis (DEA) technique was used to evaluate the operating efficiency of sugar/ethanol plants. All sugar/ethanol plants for which data are available in the Sugarcane Yearbook for the 2008/2009 harvest and that are the object of study in this paper were considered Decision Making Units (DMUs) to be compared in terms of operational efficiency.

Farrell's (1957) efficiency concepts comprise the basis for the theory of efficiency in the DEA model. The concepts were idealized by Charnes, Cooper and Rhodes (1978), who, using mathematical models, developed a technique with which it is possible to establish optimal standards of efficiency based on the relationship between outputs and inputs using linear programming.

According to Senra et al. (2007), the DEA CCR (Charnes, Cooper and Rhodes) model maximizes the quotient between the linear combination of the outputs and the linear combination of the inputs, with the restriction that for any DMU this quotient cannot be greater than 1. This problem of fractional programming, in some mathematical treatments, may be linearized and translated into the Linear-Programming Problem (LPP), in which h_0 is the efficiency of DMU_0 under analysis; x_{i0} and y_{i0} are the inputs and outputs of $DMU_{0;}$ v_i and u_j are the weights calculated by the model for inputs and outputs, respectively.

$$
\begin{aligned}
&\max \;\; h_o = \sum_{j=1}^{m} u_j y_{jo} \\
&\text{subject to} \\
&\sum_{i=1}^{n} v_i x_{io} = 1 \\
&\sum_{r=1}^{m} u_j y_{jo} - \sum_{i=1}^{n} v_i x_{ik} \leq 0 \\
&k = 1, \ldots, s \\
&u_j, v_i \geq 0 \qquad \forall i, j
\end{aligned}
$$

According to Cooper, Seiford and Tone (2007), based on the database, the efficiency of each DMU is evaluated and thus n optimizations are carried out, one for each DMU evaluated in the DEA model. In this way, an attempt is made to optimize the following equation for each DMU:

$$\frac{output}{input}$$

When multiple inputs and multiple outputs are used, the following relation is maximized:

$$\frac{output_1 + output_2 + \ldots + output_s}{input_1 + input_2 + \ldots + input_p}$$

Thus, for n DMUs, the following fractional programming is obtained:

$$\text{Max } \theta(u,v) = \frac{u_1 y_1 + u_2 y_2 + \ldots + u_s y_s}{v_1 x_1 + v_2 x_2 + \ldots + v_p x_p}$$

subject to

$$\frac{u_1 y_{1j} + \ldots + u_s y_{sj}}{v_1 x_{1j} + \ldots + v_p x_{pj}} \leq 1$$

$$u_1, u_2, \ldots, u_s \geq 0 \quad (\textit{inputs})$$

$$v_1, v_2, \ldots, v_p \geq 0 \quad (\textit{outputs})$$

in which, an attempt is made to maximize the DMU_0 result, where the optimal result corresponds to a value of θ equal to 1, in which u and v represent the weights of the input and output variables, respectively, and y and x represent the values for each input and output variable. It is necessary to restrict all model variables to non-negative values.

Since this is a linear programming technique, it is necessary to transform the fractional programming model into a linear programming model.

$$\text{Max } \theta(\mu, v) = \mu_1 y_1 + \mu_2 y_2 + \ldots + \mu_s y_s$$

subject to

$$v_1 x_1 + \ldots + v_m x_m = 1$$

$$\mu_1 y_{1j} + \ldots + \mu_s y_{sj} \leq v_1 x_{1j} + \ldots + v_p x_{pj}$$

$$v_1, v_2, \ldots, v_m \geq 0$$

$$\mu_1, \mu_2, \ldots, \quad \mu_s \geq 0$$

Methodological Aspects

This study's research method is divided into two parts, one quantitative and the other qualitative. The first phase of the research employs a quantitative approach by applying the Data Envelopment Analysis (DEA) technique to categorize and classify the universe of plants studied in relation to operational efficiency. The second phase is qualitative, in which a multiple case study is performed at plants, and interviews are conducted with specialists; the results are described using content analysis, aimed at an in-depth analysis of the data obtained in the first phase.

The DEA technique was implemented using Frontier Analyst software, manufactured by Banxia Software®. Use of the output-oriented BCC model was considered the most appropriate, by virtue of two main factors: the first concerns the fact that it is not possible to establish a proportional relationship between inputs and outputs when the productive operation of a sugarcane plant is considered; the second, related to the output orientation of the model, pertains to the growing number of new sugarcane plants in Brazil, which leads to resource scarcity, considering that efficient use can increase the level of competitiveness of these organizations and the quantity of sugar and ethanol produced.

The database used in this study was organized based on the sugarcane harvest of 2008/2009 and encompasses the total quantity, in tons, of sugarcane ground by Brazilian plants and the total quantity of sugar and ethanol produced, in tons. The DMUs are the sugarcane plants, and sugar and ethanol producers located in Brazil, according to the database.

Chart 2 shows the variables considered in this study, together with their classification in terms of input and output and their technical definition.

Chart 2. Classification of variables

Variables	Classification	Definition
Grinding (tons)	*Input*	Total amount of sugarcane, in tons, ground for the production of sugar and/or ethanol by the plant.
Sugar (tons)	*Output*	Total amount of sugar, in tons, produced by the plant.
Ethanol (tons)	*Output*	Total amount of ethanol, in m^3, produced by the plant.

Three strata were constructed for analysis of plant size according to the categories used by UNICA (2011), in which large plants are those with a grinding capacity greater than 2.5 million tons per harvest; medium plants are those with a grinding capacity of 1.0 to 2.5 million tons per harvest; and small plants are those with a grinding capacity of less than 1.0 million tons per harvest. Therefore, three basic, operational variables were used for a sugarcane plant. This study did not consider financial variables.

Then, hypothesis testing was undertaken to determine whether the population of efficient plants differs in relative terms from the population of plants as a whole with respect to the size and location variables. The statistical software used to analyze the data and generate the results is the Statistical Package for Social Sciences® (SPSS), version 18.0.

Taking into account the non-normal distribution of the input variable studied, after conducting the non-parametric KS test shown in Table 1, the binomial non-parametric test of proportions was used to test the influence of the location variable on the operational efficiency of plants and the non-parametric chi-squared test of proportions, to test the influence of the size variable.

Table 1. KS Test for distribution normality

		Grinding Variable
N	Mean	355
Normal Parameters	Std.Deviation	1583988
	Absolute	1258520
Most Extreme	Positive	,134
Differences	Negative	-,108
Kolmogorov-Smirnov Z		2,519
Asymp.Sig.(2-tailed)		,000

In the statistical tests run, the null and alternative hypotheses are as follows:

(1) Chi-squared test for the size variable:
H_0: Among the plants classified as efficient, the proportion of plants by size is the same as in the entire population of plants in Brazil.

H_1: The proportion is different.

(2) Binomial test for the location variable:
H_0: Among the plants classified as efficient, the proportion of plants in the State of São Paulo is the same as in the entire population of plants in Brazil.
H_1: The proportion is different.

The second phase of the study, qualitative in nature, includes the performance of a multiple case study at sugarcane plants through technical visits and by conducting semi-structured interviews with managers of plant agricultural and industrial departments, seeking a better understanding of the phenomenon.

To produce an overview of the study design, existing literature was used together with information obtained from three interviews conducted with specialists in the field. The interviews conducted with sugar and alcohol sector specialists were semi-structured with the objective of increasing the degree of familiarity with the object of study and to make adjustments in the variables addressed throughout the multiple case study.

It was thus possible to develop a logical case study model, as proposed by Yin (2010), which seeks to achieve the protocol objectives of the multiple case studies, as shown in Figure 3.

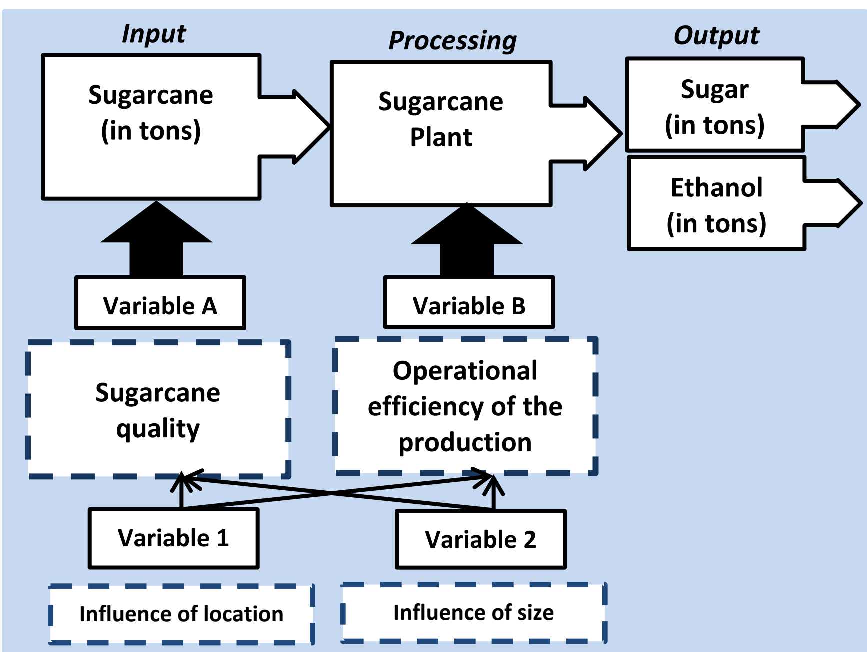

Figure 3. Logical model of the research protocol, adapted from Yin (2010)

The qualitative phase of the study had as its objective to determine how the size and location variables relate to the sugarcane quality variables and operational efficiency of the production process. The theoretical reference, along with the interviews conducted among the specialists, enabled the development of a logical model of the research protocol in order to confirm, by means of the multiple case study, the results obtained in the quantitative phase of the present study. According to Dinardo et al. (2011), among the main parameters of sugarcane quality is the

sucrose content. Thus, in this study, quality will be considered to be the apparent sucrose content in the cane.
The multiple case study was conducted with four representative sugarcane plants, chosen on the basis of the data obtained in the quantitative phase, which are presented in Chart 3.

Chart 3. Information from the multiple case study

Location		Size	Classification	Interviewed
Plant A	SP	Large	Efficient	Agriculture quality coordinator
Plant B	AL	Small	Efficient	Supervisor of agriculture controls
Plant C	SP	Medium	Inefficient	Industrial manager, production planning and control supervisor, work safety coordinator, agriculture management coordinator.
Plant D	SP	Medium	Inefficient	Industrial manager, agriculture manager, agriculture quality supervisor.

Content analysis was used as a research tool to evaluate the results of the semi-structured interviews conducted at the sugarcane plants in the multiple case studies during the qualitative phase of the research.

Results and Discussion

The results of the descriptive analysis allowed a detailed analysis of the input and output variables of the DEA model used in this study. The relation between the total amount of sugarcane available for processing and the total production of sugar and ethanol was analyzed for the set of sugarcane plants studied in connection with the 2008/2009 harvest. The plants were then evaluated for their operational efficiency. Eleven of the 355 plants analyzed in this study were classified as efficient. This represents approximately 3% of the total population of plants.

Table 2 shows the input and output values (in tons) for the eleven efficient plants according to the DEA technique used. The grinding figures represent the total volume of processed sugarcane, which constitutes the model's input variable. On the other hand, the sugar and ethanol values represent the values produced throughout the 2008/2009 harvest and constitute the model's two output variables.

It is possible to observe that eight of the eleven plants considered efficient are located in the State of São Paulo, whereas, in relation to size, there are five large, two medium and four small plants in the group of efficient plants. According to Salgado Junior, Bonacim and Pacagnella Junior (2009), efficiency in DEA analyses is independent of the size of the plant, because it is the proportionality between the inputs and outputs in the model that make the DMU efficient or not. After completion of the hypothesis testing, it was possible to determine whether this group of plants can be considered significantly different from the general plant population. However, it is important to note that efficiency in DEA is always relative, taking into account the DMUs that belong to the group of plants analyzed in this study.

Table 2. Efficient plants

Sugar/Ethanol Plant	State	Size	Grinding Variable (tons)	Sugar (tons)	Ethanol (m^3)	*Score*
Usina da Barra S/A Açúcar e Álcool da Barra	SP	Large	7,378,408	499,772	315,804	100.00
Usina da Barra S/A Açúcar e Álcool de Bonfim	SP	Large	4,785,973	371,412	193,029	100.00
Açúcar Guarani S/A	SP	Large	4,436,982	459,022	78,592	100.00
Andrade Açúcar e Álcool S/A	SP	Large	3,187,694	183,794	200,881	100.00
Usina de Açúcar Santa Terezinha Ltda.Ivaté	PR	Medium	2,001,450	222,151	46,061	100.00
Aralco S/A Indústria e Comércio	SP	Small	833,436	106,57333	0	100.00
Companhia Brasileira de Açúcar e Álcool Filial ICEM	SP	Small	405,029	59,212	0	100.00
Usina São Martinho S/A	SP	Large	8,004,221	445,903	411,991	100.00
Usina Santa Adélia S/A Filial Usina Interlagos	SP	Medium	2,151,099	0	184,880	100.00
Laginha Agro Industrial S/A Matriz	AL	Small	630,349	0	72,752	100.00
Companhia Usina Bulhões	PE	Small	72,612	0	9,653	100.00

Regarding the location variable, Table 3 shows on a state-by-state basis the frequency of efficient plants compared to the frequency obtained for the entire population.

Table 3. Frequencies by location

State	Efficient Plants	Total Population
São Paulo	8 (72.7%)	170 (47.9%)
Minas Gerais	-	32 (9%)
Paraná	1 (9.09%)	28 (7.88%)
Mato Grosso do Sul	-	14 (3.94%)
Goiás	-	28 (7.88%)
Mato Grosso	-	11 (3.1%)
Alagoas	1 (9.09%)	24 (6.76%)
Pernambuco	1 (9.09%)	23 (6.48%)
Outros estados somados	-	25 (7,04%)
Total	**11 (100,00%)**	**355 (100,00%)**

Among the efficient sugarcane plants operating in Brazil, a significant number of them are located in the state of São Paulo. Although there are many inefficient plants in the state of São Paulo, the proportion of plants in the state of São Paulo in the efficient group is greater (73%) than that of the total population of plants in Brazil (47.9%).

Table 4 shows the statistical analysis of the location variable.

Table 4. Statistical test for location

	Category	**Location**	**Number Observed**	**Test Prop.**	**Exact Sig. (1-tailed)**	**Sig.**
Location	Group 1	State of São Paulo	8	.727	.479	.090
	Group 2	Other states	3	.273		
	Total		**11**	**1.00**		

Besides the location variable, another important variable in the study is the size of the sugarcane plants, when compared to their efficiency. The chi-squared test was used to test for differences in proportions in relation to this variable. Table 5 shows the observed frequencies for the group of efficient plants and for the total population in relation to size.

Table 5. Frequencies by size

	Efficient plants	**Total Population**
Large Plants	5 (45.5%)	60 (16.9%)
Medium Plants	2 (18.2%)	163 (45.9%)
Small Plants	4 (36.3%)	132 (37.2%)
Total	**11 (100.0%)**	**355 (100.0%)**

Table 6 tests the null hypothesis (H_0) that the frequencies observed in the group of efficient plants sampled are equal to the frequencies observed in the total population, that is, the group of all plants studied.

Table 6. Chi-squared test

	Observed N	**Expected N**	**Residual**
Large Plants	5	1.9	3.1
Medium Plants	2	5.1	-3.1
Small Plants	4	4.1	-.1
Total	**11**		

Considering that 16.9% of the total population consisted of large plants, 45.9% medium plants and 37.2% small plants, the values expected for the sample of 11 plants were 1.90 (16.9%) large plants, 5.10 (45%) medium plants and 4.10 (37.2%) small plants. However, the actual values observed in the group of efficient plants were 5 (45.5%) large plants, 2 (18.2%) medium plants and 4 (36.3%) small plants. Table 7 shows the statistical analysis of the size variable.

Table 7. Statistical test for size

	Size
Chi-Square	7.149
DF	2
Asymp.Sig.	.028

It is possible to state that, in relation to the size variable, the sample is different from the population, that is, at a significance level of 95%, the null hypothesis (H_0) can be rejected, which means that the proportions observed for efficient plants are different from the proportions found for the total population of plants with respect to size.

The size variable, as well as the location variable, therefore exerts some influence on the capacity of plants to operate with greater efficiency. In order to verify the results of the statistical analyses, multiple case studies were conducted at the various sugarcane plants.

The results of the qualitative phase of the present study are shown below. First, an attempt was made to ascertain the factors that enable sugarcane plants to realize greater operational efficiency and then to analyze the possible impact of the size and location variables on such factors. Based on the interviews conducted with the specialists, it was possible to obtain evidence that operational efficiency is related to higher quality sugarcane, which allows more juice to be extracted, thus resulting in greater sugar and ethanol production. Operational efficiency may also be related to the use of technologically more sophisticated machinery and equipment on the production line, permitting greater productivity.

Chart 4 shows the main results obtained in the multiple case study in relation to sugarcane quality, which is influenced by the weather and soil conditions (Variable A) and the operational efficiency of the production process (Variable B) for the four plants studied.

Based on the interviews conducted, especially in the multiple case studies at plants A, C and D, it was possible to make the assumption that, by virtue of high fixed costs inherent to sugarcane plant installations, managers seek to use the maximum installed production capacity because an increase in the volume processed by the plant means a higher financial gain. It was noted that some equipment or technologies that the plants have can provide greater operational efficiency.

However, based on the interviews with specialists and the multiple case studies, especially at plants C and D, evidence was obtained that it is more cost-effective to increase the quantity of processed sugarcane than to increase sugar and ethanol productivity by the plant. Therefore, the study conducted suggests that initially there should be greater investment in increasing sugarcane grinding capacity; that is, an increase in the volume of processed sugarcane and subsequent investment in equipment and technologies that permit increased operational efficiency. Thus, investments in technology would be an alternative for plants that would no longer have the means to increase grinding capacity. Consequently, these would be large plants.

This result corroborates the conclusions of Romão Junior (2009) that some equipment represents a big investment with high implementation costs and, for this reason, bears a relationship to the size and operational characteristics of the plants.

Chart 4. Results found in the multiple case study

	Location	Size	Classification	*Score*	Variable A – Weather and Soil Conditions	Variable B – Operating Efficiency of the Production Process
Plant A	SP	Large	Efficient	100.00	Tropical climate	Predominantly mechanized harvest, use of a grinder, SLCS, use of continuous fermentation, molecular sieve for anhydrous recovery, use of a filter in treating the broth.
Plant B	AL	Small	Efficient	100.00	Wet, coastal climate/ reddish-yellow and clay latosols	Manual harvesting, use of a grinder, continuous fermentation, use of filters for treating broth and evaporators.
Plant C	SP	Medium	Inefficient	91.27	Tropical climate; acrid latosols	Predominantly mechanized harvest, use of a grinder, sugarcane cleaned predominantly with water, does not use other equipment in production.
Plant D	SP	Medium	Inefficient	87.77	Tropical climate; acrid latosols	Predominantly mechanized harvest, use of a grinder, sugarcane not cleaned, filter used for treating broth, fermentation by batches

The main equipment or technologies that permit gains in efficiency, based on the interviews, were the dry sugarcane cleaning system (SLCS) and the filter for treating the broth. In relation to Variable 2, regarding the operational efficiency of the production process, combustion of sugarcane is a factor that proved relevant to the study, since it can eliminate sugarcane straw, which hampers broth extraction. Thus, the method for harvesting sugarcane in the field has consequences for the quantity of straw (plant impurity) and soil (mineral impurity) in the sugarcane at the moment it enters the production line, which could influence broth extraction.

However, the sugarcane cleaning process precedes broth extraction and tends to facilitate its extraction using grinders and / or diffusers. During the sugarcane cleaning process, it is possible to clean the system with water or to employ the SLCS, or dry sugarcane cleaning system. This reduces the silica and removes sugarcane straw, which, in turn, contributes to greater sugarcane extraction capacity and avoids waste. Based on the cases studied, this step proved relevant to the extent that it is able to influence the quantity of impurities impinging on the production process.

Corroborating the study by Ribeiro (2008), there is evidence that manual harvesting is less frequent in the state of São Paulo, where sugarcane is harvested with harvesters that expel some of the straw without the need for burning. Thus, the SLCS proved to be an important technology, capable of permitting sugarcane to enter the production line without the interference of plant and mineral impurities that could hamper grinder or diffuser action. In this respect, scale was identified as an important factor in relation to the operational efficiency of the production

process, since greater scale justifies investment in equipment that takes better advantage of the tons of sugarcane that enter the production line.
Based on a literature review followed by interviews with specialists and the multiple case studies conducted at the plants, it was possible to obtain evidence that the soil and climate, which together comprise the edaphoclimatic factors, are important and impactful determinants of sugarcane quality. Cesar et al. (1987) support these results, stating that there are several factors that interfere in sugarcane production and maturation, such as edaphoclimatic interaction, crop management and the sugarcane variety chosen. Crop management and genetic variety, however, are aspects of the production process that seek to take utmost advantage of the production environment's agricultural potential, that is, to enable the full use of the soil's production potential.

Plant A and plant B were used as evidence of the significance of climatic and soil factors, since these two plants, classified as efficient in the quantitative phase of the study, are located in regions with favorable production environments. Corroborating the statements by Smeets et al. (2009), Torquatro, Martins and Ramos (2009) and Martinelli et al. (2011), there is evidence that the state of São Paulo is located in a region with favorable edaphoclimatic factors for the sugarcane crop.

There is a concentration of plants located in the northeast region of the State of São Paulo that coincides with the location of red earth, or red latosol (LR). According to the Agência de Informação Embrapa (2012), red earth is one of the soils of great agricultural importance and high production potential, responds well to fertilizer and soil correction and is well suited for crops and other agropastoral uses. According to Ker (1997), the favorable conditions for agriculture in red latosol areas (Rio Grandense plateau, northern Paraná, parts of São Paulo, especially Ribeirão Preto, southeastern Goiás, Dourado and Tangará da Serra) appear to confirm the high agricultural potential of this soil type, because of its natural fertility, ease of and response to fertility correction when needed, and ample potential for mechanization and irrigation in some locations.

Corroborating such claims, according to Sobiologia (2012), red earth is a soil that stands out due to its fertility and occurs in the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo and Mato Grosso do Sul.

Plant A is located in a region where the predominant soil can be classified as red latosol, or simply red earth. Plant B, on the other hand, is located in a region whose soil is classified as reddish-yellow latosol. According to Ker (1997), reddish-yellow latosol is the most abundant latosol in Brazil with the widest geographic distribution. Latosols vary considerably in their natural fertility and occur in areas ranging from flat relief (plateaus) to mountainous. Plant A and plant B are classified as efficient.

Chart 5 reproduces the final portion of Yin's (2010) case study in which triangulation of the various lines of evidence obtained in the present study converges to the results presented in Chart 5. The authors who addressed each of these factors, relating them to efficiency in the plants, are listed followed by the plants that, on the basis of the multiple case study, made possible an analysis of the influence of each factor on operational efficiency and, finally, the interview with the specialist that provided further evidence pertaining to the results obtained in the study.

Chart 5. Triangulation of results found

Variables		Factors	Literature Review	Case Study	Specialists
Operational efficiency	Sugarcane quality	Soil	Smeets et al.(2008); Cesar et al.(1987); Lepsch (1987); Maule, Mazza and Martha-Junior (2001); Staut (2012); Embrapa (2012).	Plants A, B	Owner of an input organization for planting sugarcane.
		Climate	Smeets et al.(2008); Cesar et al.(1987); Maule, Mazza and Martha-Junior (2001); Netafim's Agriculture Department (2012).	Plants A, B	Owner of an input organization for planting sugarcane.
	Production process	Dry cleaning the sugarcane	Sermatec (2012); Empral (2012); Romão Junior (2009).	Plants A, C, D	Prof.Dr.UNESP Jaboticabal.
		Filter for cleaning broth	Agência de Informação Embrapa (2012); REDETEC (2012).	Plants A, C, D	Prof.Dr.UNESP Jaboticabal.

Therefore, based on multiple sources of evidence used in this study, there are indications that production environments favorable to sugarcane extraction with higher sucrose content are more common in the state of São Paulo, making gains in operational efficiency possible. There is also evidence that the large plants have greater motivation to invest in equipment and technologies that permit gains in operational efficiency within the sugar and ethanol production process, such as SLCS and the broth treatment filter.

However, it is important to observe that there are plants located in the state of São Paulo that were classified as inefficient. Although this state has regions with edaphoclimatic factors that favor the sugarcane crop, the state of São Paulo also has regions with less favorable production environments, as seen in plant D. Likewise, ripe conditions for the sugarcane crop can also be found in other states, as seen in plant B. Thus, although favorable edaphoclimatic conditions can be found in the state of São Paulo with greater frequency, the same conditions can also be found in other states.

According to Torquatro (2006), new investments in Brazil are on the rise in the Midwest, especially in the states of Mato Grosso do Sul, Mato Grosso and Goiás. In southern Brazil, Paraná is already the second largest producer of sugarcane in the country, trailing only São Paulo. The new tendency to invest in other regions occurs mainly by virtue of high startup costs in the southeast. Goiás is one of the states showing the most growth in terms of sugarcane volume in recent years, according to the IBGE (2011). The occupation of new areas along the border and the reduction in production costs have become the basis for growth in agricultural production in Goiás (Bezerra and Cleps Jr 2004).

Table 8 shows an analysis of efficiency scores based on application of the DEA technique to plants located in the main sugarcane producing states in Brazil.

Table 8. Descriptive analysis of efficiency scores by state

States	No. of plants	Average	Standard deviation	Maximum	Minimum
São Paulo	170	85.20%	10.05%	100%	56.09%
Minas Gerais	32	79.74%	11.35%	98.57%	50.48%
Paraná	28	79.29%	10.66%	100%	61.88%
Mato Grosso do Sul	14	79.43%	10.13%	95.99%	65.57%
Goiás	28	73.84%	11.35%	93.14%	41%
Mato Grosso	11	77.37%	15.28%	94.82%	44.83%
Alagoas	24	82.18%	7.64%	100%	67.38%
Pernambuco	23	79.56%	11.26%	100%	51.47%

Of the 355 existing plants in Brazil, according for the sugarcane yearbook, during the 2008/2009 harvest, 327 plants are located within the territorial limits of the states listed in Table 8, which corresponds to 92.11% of all plants in Brazil.

The state of Alagoas has the second highest average among all states analyzed, at 82.18%, and the lowest standard deviation.The state has reddish-yellow latosols, which, according to Ker (1997), is the most abundant latosol in Brazil with the most widespread geographic distribution. Latosols show considerable variability in their natural fertility and are found in areas that vary from flat relief to mountainous.Although the state of Pernambuco has similar edaphoclimatic conditions, it has an average efficiency of 79.56% and standard deviation of 11.26%. The state of Goiás has the lowest average efficiency rating among the states listed, and a standard deviation of 11.35%. This state has no efficient plants, according to the quantitative analysis developed in the present study. The states of Minas Gerais, Mato Grosso and Mato Grosso do Sul show similar results. One possible factor that could explain the results obtained is the wide variety of different soil types. Mato Grosso still has a slightly lower average value and the biggest standard deviation among those analyzed, at 15.28%. There was a plant in Paraná classified as efficient with an average score of 79.29% and a standard deviation of 10.66%. The state of São Paulo has the highest average efficiency rating, at 85.20%, with a standard deviation of 10.05% and is also the state with the largest number of plants classified as efficient.

Therefore, as seen in plant B, installation in a region with favorable edaphoclimatic factors, together with use of technologies that make gains in efficiency possible, permits maximization of productivity from an operational perspective. The state of Alagoas thus proved to be propitious for the installation of sugar/ethanol plants.

The state of Goiás, on the other hand, despite recent tendencies to increase the quantity of sugarcane processed, does not have a big yield in terms of production. However, it represents a state with potential because it has favorable climatic conditions and specific regions with favorable soil, including red latosol. Thus, it is up to the investor to develop a sugar/ethanol plant capable of developing quality sugarcane and to reap the benefits of this factor through the proper use of technology.

Therefore, it is not enough to simply install sugar/ethanol plants in regions with favorable edaphoclimatic factors. In order to obtain maximum operational efficiency, it is necessary to have a combination of quality sugarcane, along with use of technologies and equipment that enable the optimal use of this raw material for the production of sugar and ethanol.

This made it possible to create Chart 6 (See Appendix), which presents the major observed characteristics of various states in Brazil, from which it was possible to map the sugarcane plants based on their operational efficiency, taking into consideration the agricultural potential of the different states.

Conclusions

Based on the evidence collected in this study, it is possible to make assumptions leading to the conclusion that in the group of efficient plants, there is a higher concentration of plants located in the state of São Paulo in terms of the location variable and a higher concentration of plants whose size is classified as large in terms of the size variable.

With regard to the location variable, the results obtained suggest that, in the state of São Paulo, the soil and climate, that is, the predominant edaphoclimatic factors, contribute to sugarcane of better quality, with a higher level of sucrose, thus permitting greater operational efficiency and, consequently, greater production of sugar and ethanol from the same volume of sugarcane.

It is important to note that, although edaphoclimatic factors predominate in São Paulo, which explains the higher proportion of efficient plants in the state, these factors can be found, in lower proportions, in other states in Brazil. This explains the existence of plants outside the state of São Paulo, classified as efficient, as in the case of plant B,, which is located in the state of Alagoas, in a region with favorable edaphoclimatic factors for growing sugarcane.

Thus, the installation of new sugar/ethanol plants is justified in regions of Brazil that have favorable edaphoclimatic conditions but lower production costs. States that proved to be potentially favorable for the sugarcane crop strictly from the perspective of the operational efficiency of sugar/ethanol plants were Alagoas, Pernambuco and specific regions of Minas Gerais, Paraná and Mato Grosso do Sul, which have favorable edaphoclimatic conditions. The state of Goiás proved to have the lowest average efficiency among the most important sugarcane producing states in Brazil, but has high agricultural potential, especially by virtue of the favorable climatic conditions and the existence of regions that have favorable soils for growing sugarcane. However, investments in technology should be made in the interest of seeking increases in efficiency.

In relation to the size variable, there are indications that large plants have greater motivation to invest in technological equipment that allows for a more efficient production process. Two technologies that showed evidence of exerting an important influence on operational efficiency were SLCS and the broth treatment filter. Conducting SLCS and using filtration to treat broth are technologies that could provide greater operational efficiency and tend to be more frequently used in plants that operate on a large scale, since they are unable to invest in an increase in factory capacity owing to the fact that they are already at the limit of their production capacity.

Therefore, investment in technologies and equipment providing efficiency gain in the total quantity of sugar and ethanol produced is fundamental in order to maximize operational efficiency, as well as to take full advantage of edaphoclimatic factors.

Acknowledgement

This research was supported by the National Counsel of Technological and Scientific Development (CNPq).

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Appendix

Chart 6. Map of the agricultural potential in Brazil's main states

State	Average Relative Operational Efficiency	Characteristics	Recommendations
São Paulo	85.20%	Predominance of favorable edaphoclimatic conditions for growing sugarcane, greater operational efficiency of plants by state, high cost of land.	Good conditions favor the plants' operational efficiency; it is necessary to consider possible high production costs with eventual gains in efficiency.
Alagoas	82.18%	Second highest average operational efficiency by state, existence of regions with favorable types of soil for growing sugarcane, such as reddish-yellow latosol. Lowest standard deviation for the efficiency score by state.	Region is good for the production of sugar and ethanol; investment in technologies [needed] where a [high] frequency of favorable edaphoclimatic conditions [prevail].
Minas Gerais	79.74%	Climatic conditions favorable for growing sugarcane; variability of soil types; existence of favorable soils; high variability of average operational efficiency.	Necessary to invest in specific regions with favorable edaphoclimatic factors; important to increase investment in equipment and technologies to increase efficiency.
Pernambuco	79.56%	High variability in soil and climate; existence of regions with favorable soils for growing sugarcane.	Presence of favorable edaphoclimatic conditions. High agricultural potential; more investment needed in equipment and technology.
Mato Grosso do Sul	79.43%	High variability in soil types and climate. Existence of reddish-yellow and red latosols.	Search for specific edaphoclimatic conditions, found at lower frequency in the state, plus investment in equipment.
Paraná	79.29%	Existence of soils favorable for growing sugarcane; frequency of red latosol and predominantly wet, tropical climate.	Certain favorable regions whose edaphoclimatic factors favor investment; investment in equipment and technology needed to increase efficiency.
Mato Grosso	77.37%	Highest standard deviation for the average operational efficiency score; high variability in soil types and climate.	Search for specific edaphoclimatic conditions, found at lower frequency in the state, plus investment in equipment.
Goiás	73.84%	Lowest average operational efficiency among those states studied; favorable climate and high variability in soil types; existence of red latosol.	Investment needed in equipment and technologies. Represents great agricultural potential by virtue of the frequency of favorable edaphoclimatic conditions.

International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Who Attends Farmers' Markets and Why? Understanding Consumers and their Motivations

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Abstract

This study assesses consumer motivations for attending farmers' markets through in-person survey data. Results indicate that consumers attend primarily to purchase fresh produce, followed by social interaction. Purchasing ready-to-eat foods or packaged foods, arts, and crafts were not strong motivators. Consumers attending primarily to purchase fresh produce tend to be married females at higher income levels, individuals with strong diet or health concerns, and individuals who are supportive of local farming and agriculture open space. Those attending for social interaction are more likely to be unmarried males or larger families attending events. Implications for market vendors, managers, and policy makers are discussed.

Keywords: Farmers' markets, fresh produce, attendance motivations, target consumers

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Introduction

The number of farmers' markets in the United States has grown rapidly over the past few decades. Between 1970 and 1986, farmers' markets in some states increased tenfold, with the national total rising nearly 500% (Brown 2001). Growth continued in the early twenty-first century, with the number of markets increasing by 184% from 2000 to 2013 (2,863 to 8,144) (USDA-AMS 2014). Such growth could be attributed to economic factors such as the need for local growers to diversify their sources of income (Brown 2002). Other arguments include that socioeconomic effects that markets have on communities, such as job growth (Curry and Oland 1998), as well as consumer demand for fresh local produce and provision of setting for social interaction and a sense of community (Oberholtzer and Grow 2003; Brown and Miller 2008). Others (Sommer et al. 1981; Hilchey et al. 1995; Cassia et al. 2012) conclude that the existence of farmers' markets allows for the preservation of open spaces and improves the customers' psychological satisfaction.

The literature on farmers' market consumers has focused primarily on consumer preferences and willingness to pay for locally grown and organic produce (Loureiro and Hine 2002; Dimitri and Greene 2004; Gifford and Bernard 2004; Zepeda and Leviten-Reid 2004; Garmon et al. 2007; Keeling-Bond et al. 2009; Curtis and Cowee 2011). Literature examining additional motives for attendance at farmers' markets is limited. The existing studies (Darby et al. 2008; George et al. 2011; Alonso and O'Neill 2011; Murphy 2011) indicate that consumers attend farmers' markets to purchase fresh, high-quality produce and interact with growers. A more detailed analysis is necessary for produce growers, market managers, and policy makers interested in enhancing sales of all goods and services available at markets or seeking to increase fresh produce sales or consumption among consumers.

This study analyzes consumer motivations for attending farmers' markets. The four primary motivations considered were purchasing produce, purchasing ready-to-eat foods, social interaction, and purchasing packaged foods, arts, or crafts. These motives were selected on the basis of products, services, and events available at the farmers' markets examined as well as consumer attendance motives suggested by previous studies (Oberholtzer and Grow 2003; McGarry-Wolf et al. 2005; Brown and Miller 2008; George et al. 2011; Alonso and O'Neill 2011). Literature examining event attendance motivations can be found in the tourism and sports literature (Faulkner et al. 1999; Pegg and Patterson 2010; Nicholson and Pearce 2001; Lee et al. 2010), where survey data is analyzed primarily using factor and/or cluster analysis to identify target consumers by attendance motivation (Middleton 2001; Mair 2010).

This study describes the consumer characteristics, attitudes, and concerns that determine the probability of visiting a farmers' market primarily to purchase produce, as well as the relative probabilities of attending a farmers' market for other reasons. We also analyze consumer types among attendance motivations and formulate managerial and policy implications. Although this study uses data collected from farmers' markets in Utah and Nevada, the findings are likely applicable to farmers' markets throughout the West that offer similar products and services.

Review of Literature

Farmers' markets offer opportunities for local farmers and small businesses to sell directly to consumers, grow a customer base, and test new products and pricing strategies. Farmers' markets also provide opportunities for consumers to purchase fresh, high-quality produce, attend educational events and concerts, and to socialize. Sommer et al. (1981) compared the social and physical attributes of supermarkets and farmers' markets in California and found that customers perceived farmers' markets as more personal, rural, smaller, and friendlier settings than traditional supermarkets. Neil (2002) claimed that farmers' markets are important because they give local farmers the chance to sell the food they raise directly to customers and allow consumers to buy fresh food from the farmers who raise it, providing the opportunity to reconnect consumers with the food supply chain. In addition to produce, other goods and services are available at farmers' markets, including arts and crafts, ready-to-eat foods, beverages, breads, and packaged products (USDA-AMS 2009). Farmer's markets also provide communities the opportunity to create excitement and activity in downtown areas and local neighborhoods.

The literature discussing consumer motives for attending farmers' markets clearly indicates that consumers attend farmers' markets primarily to purchase local produce. While some studies mention other potential motives, they do not specifically analyze these motives. For example, Lyon et al. (2009) used a survey of 391 consumers at farmers' markets in five Scottish towns in 2006 and reported that consumers sought high-quality food products and direct contact with local produce growers. McGarry-Wolf et al. (2005) compared consumer motivations through the use of in-person surveys conducted at grocery stores and farmers' markets in San Luis Obispo County in California and found that consumers perceived produce at farmers' market to be fresher looking, fresher tasting, of higher quality, better value for the money, more reasonably priced, environmentally friendly, and traceable to the growers. They indicated that many consumers do not shop at farmers' market because of convenience issues but didn't examine the reasons for farmers' market attendance outside of produce purchases.

Trobe (2001) interviwed famers' market consumers in the United Kingdom during the first three months of the market to investigate the reasons for their attendance as well as their attitudes toward a number of food issues, including organic and genetically modified (GM) food, local and seasonal food, and concerns they had over the way their food was produced. Customers visited the markets initially out of curiosity, although some attended specifically to buy fresh food. Respondents had strong preferences for organically grown and GM-free food.

Archer et al. (2003) surveyed a sample of consumers, many of whom were not familiar with the term "farmers' market." They found that consumers generally perceived that farmers' markets sell fresh, quality, locally produced, tastier, healthier, and seasonal food, but expect the food to be higher priced. The majority of individuals who had previously shopped at a farmers' market returned because of the availability of a large variety of fresh, local produce and to support local growers.

Despite the large growth in farmers' markets and the popularity of such markets, very little is known about the types of consumers who attend these markets and their motivations. Existing studies have focused on consumer demand for specialized or labeled products (local, organic, GM-free, etc.) or attempted to explain why consumers choose to purchase fresh produce at farmers' markets rather than more traditional grocery outlets. Since farmer's markets offer a variety of products beyond fresh produce as well as other services and activities, the role they play in increasing market patronage is a relevant question. This study examines a variety of attendance motives and provides an overview of representative consumer characteristics, concerns, and attitudes by motive.

Model Specification

This analysis employs a random utility framework. Suppose an individual *i* is assumed to choose the alternative that gives the highest utility among *J* alternatives. In this study, four alternatives are analyzed: purchasing produce, purchasing ready-to-eat food, social interaction, and buying packaged foods, arts and crafts. The utility function takes the form

1) $U_{ij} = V_{ij} + \varepsilon_{ij}$ for $i = 1,\ldots,I$ and $j = 1,\ldots,J.$

where V_{ij} is the deterministic component of the utility and ε_{ij} is the random component. The analysis assumes that the random component term is independently and identically distributed (iid) extreme value $F(\varepsilon_{ij})=exp(-exp(-\varepsilon_{ij}))$ so that the logistic model becomes appropriate (Kennedy 2008). It also assumes a linear-in-parameters functional form for the deterministic component of utility (Onozaka and Thilmany-McFadden 2011). The indirect utility V_{ij}^{*} for individual *i* choosing an alternative *j* is

2) $V_{ij}^{*} = \beta' X_{ij} + \mu_{ij}$ for $i = 1,\ldots,I$ and $j = 1,\ldots,J.$

where X_{ij} is a vector of characteristics of the consumers at farmers' markets. The parameter vector β is to be estimated. The μ_{ij} is the disturbance that accounts for unobserved factors.

Two versions of the random-utility model described are used in this study, a binary logistic and a multinomial logistic (MNL) model. The logistic model for binary responses explains the effects of consumer characteristics on the probability of attending a farmers' market to purchase fresh produce. To estimate the relative probabilities of attending a farmers' market due to a particular motive as opposed to purchasing produce, a MNL model is used. This model allows us to predict the probability that the j^{th} alternative of the whole set of motives is chosen to be the best primary reason for which the respondent came to the farmers' market. The probability (*P*) that an individual *i* chooses to attend primarily due to a motive *j* is

3) $P_{ij} = P(y_i = j) = \dfrac{exp(\beta_k^{'} X_{ij})}{\sum_j \beta_k^{'} X_{ij}}$

Purchase produce is the reference category in this analysis and the estimated parameters are interpreted relative to this category. The null hypothesis is that each independent variable has no impact on the relative probability of attending a farmers' market for purposes other than purchasing produce. The alternative hypothesis is that the variables in the vector X have statistically significant impacts on the probability of attending a farmers' market for purposes of social interaction, purchasing ready-to-eat foods, or buying packaged foods, arts and crafts; that is, $H_0 \equiv \beta_{kj} = 0;\ \forall k = 1,\ldots,K;\ j = 1,\ldots,J$ for K regressors and J choice alternatives/motives and $H_1 \equiv \beta_{kj} \neq 0;\ \forall k = 1,\ldots,K;\ j = 1,\ldots,J$ for K regressors and J choice alternatives/motives.

Data and Variables of Interest

This study uses in-person survey data collected across sixteen farmers' markets in Nevada during the summer of 2009 and Utah during the summer of 2011. Each market was sampled at least three times throughout the season. A total of 1,488 farmers' market consumers completed the survey—669 in Nevada and 819 in Utah. The survey contained questions concerning consumer preferences for product and farmers' market attributes, purchasing habits, and attendance frequencies as well as attitudinal and demographic characteristics (see Table 1 for sample variable summary statistics).

Using a strategy similar to Pascucci et al. (2011), respondents were randomly selected from among attendees leaving the market after completing their purchases. The average respondent was forty-two years old and had completed a four-year college degree; 55% of respondents were from Utah and 45% from Nevada. The average household size was three, 66% of respondents were female, and 62% were married. More than half (58%) had their own home garden, 80% were the household's primary shopper, and 44% reported that they would be willing to join a community supported agriculture (CSA) program.[1]

Two additional dummy variables, "spend above average" and "income above average," were included. Spend above average is equal to 1 if a respondent spent more than the sample average, \$24.78, at each farmers' market visit and 0 if they spent below the sample mean. About 48% of respondents spent above the average during each farmers' market visit. Income above average is equal to 1 if a respondent's income is above the sample average, \$75,420, and 0 otherwise. Approximately 57% of the respondents had an annual income above the sample average. This suggests that higher income individuals are more likely to attend farmers' markets than those with lower incomes.

Other attitudinal variables were examined as well, including whether an individual has little time to prepare meals at home, concerns for food safety, concerns for diet or health, buying products with low environmental impact, and enthusiasm for agriculture (see Table 1). Agriculture enthusiasts refer to individuals who consider "open space for agriculture use" and "supporting local farmers" to be either important or extremely important. Each of these variables was rated on a scale from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree."

[1] A CSA is a subscription program in which consumers purchase a weekly basket of fresh produce from a local farm.

Table 1. Sample Descriptive Statistics

Variable	Description	Mean
Outcome 1: Purchase produce	Primary motivation is to purchase fresh produce	0.73
Outcome 2: Buy ready-to-eat foods	Primary motivation is to buy ready-to-eat foods	0.04
Outcome 3: Social interaction	Primary motivation is to socialize, attend concerts/music and event/activities	0.15
Outcome 4: Buy packaged foods, arts, or crafts	Primary motivation is to purchase arts/crafts and packaged foods	0.07
Age	Age of a respondent	42 (15)
Visits	Number of farmers' market visits per season	4 to 7
Family size	Total number of people in a household	2.6 (1.43)
Education	Respondent' level of education. 1=middle school, 2=high school, 3=some college, 4=2-year associate degree, 5=4-year college degree, and 6=graduate	4.4 (1.33)
Time to prepare meals	5 point scale degree of agreement a respondent has about having little time to prepare meals	3.5 (0.72)
Food safety concern	5 point scale degree of agreement about food safety	3.7 (0.70)
Concern for diet/health	5 point scale degree of agreement about diet concerns	3.1 (1.22)
Environment impact	5 point scale degree of agreement a respondent has about buying products with low environmental impact	4.4 (0.81)
Agrienthusiast	An average of the responses to "Agricultural open space" and "supporting local growers" is important to me rated on a 5 point scale (1 = strongly disagree, 2 =disagree, 3 = unsure, 4 = agree, 5 = strongly agree)	4.4 (0.77)
Presence attributes	Average of the responses to the importance of the number of vendors, family/child activities, variety of products, and food/beverage vendors rated on a 5 point scale (1 = not important, 2 = slightly important, 3 = somewhat important, 4 = very important, 5 = extremely important).	3.5 (0.91)
Convenience attributes	Average of the response to the importance of the hours of operation, location, free parking, and music rated on a 5 point scale (1 = not important, 2 = slightly important, 3 = somewhat important, 4 = very important, 5 = extremely important).	4.2 (0.74)
Spend above average	Spending at the farmers' market is above sample average ($24.78); Yes=1 and 0 below the average (of expenditures reported by respondents)	0.48
Income above average	Income is above sample average ($75,420); No=0, Yes=1. Average of incomes reported by respondents)	0.567
Primary shopper	Is a primary shopper; No=0, Yes=1	0.80
CSA	Would join a CSA program; No=0, Yes=1	0.44
Favorite vendor	Has a favorite vendor; No=0, Yes=1	0.33
Home gardening	Has a home garden; No=0, Yes=1	0.58
Female	Respondents' gender; Male=0, Female=1	0.66
Married	Respondents' marital status; Single=0, Married=1	0.60
UT	Respondents' residence; Nevada=0, Utah=1	0.55

Note. Standard errors are in parentheses.

On average, respondents were unsure about having enough time to make meals at home. They were generally concerned with their health or diet, food safety, and buying products with low environmental impact, meaning that the average rating was four. Consumers at farmers' markets agree that agricultural open space and supporting local farmers is important to them.

Consumer attitudes toward farmers' market attributes were also included. Survey respondents were asked to rate farmers' market attributes on a scale from 1 to 5, where 1 was "not important" and 5 was "extremely important"). The survey included eight attributes, which were condensed into two categories to reduce the number of explanatory variables. The first category consisted of attributes that relate to the physical setup and services present in the market, or "presence" attributes, including the number of vendors, family/child activities, variety of products, and food/beverage vendors. The second category consisted of the attributes that make a farmers' market more convenient, or "convenience" attributes, including convenient location, hours of operation, free parking, and music/concerts. Both variables were rated a 4 (very important) on average by respondents (Table 1). In addition, no evidence of correlation among the variables in the model was found. The highest correlation was between concerns for diet or health and food safety concerns (0.3853).

One survey question provided a list of seven possible attendance motivations and asked respondents, "What is your primary motive for attending the farmers' market? (Check only one)." The seven options included purchasing fresh produce, purchasing packaged foods, purchasing arts/crafts, social interactions, attending events/activities, attending concerts/music, and purchasing ready-to-eat food. The choice set was selected based on the products, services, and events available at all sixteen farmers' markets. As some of the choice alternatives had few observations, these seven were condensed down to four primary motivations. Closely related motivations were combined to reduce model categories and account for low frequencies among some motives (Kennedy 2008). Thus, the four primary motivations considered in this analysis are: (1) purchasing produce, (2) social interaction (condensing social interaction, concerts/music, and event/activities), (3) purchasing ready-to-eat food, and (4) purchasing packaged foods, arts, or crafts (condensing purchasing arts/crafts and purchasing packaged foods).

In the binary logistic model, these responses are coded as 1 for the primary motive of purchasing produce and 0 otherwise. The dependent variable for the MNL analysis is therefore organized around the four primary motives for farmers' market attendance. As shown, 73% of respondents attend farmers' market primarily to purchase produce, while others attended to socialize (15%), buy packaged foods or arts and crafts (7%), and buy ready-to-eat food (4%). The market share for fresh produce growers (almost 75%) outweighs the share remaining for the other vendors (about 25%).

Results

Attending Farmers' Markets to Purchase Fresh Produce

Results of the binary logistic model (Table 2) show that married female respondents involved in home gardening, who visit farmers' markets frequently, and who are agriculture enthusiasts are more likely to attend primarily to purchase produce. Those with large families and those who don't have time to cook meals at home are less likely to attend farmers' market primarily to purchase fresh produce.

Table 2. Logistic Coefficient Estimates and Marginal Effects (Purchase Produce)

	LR chi2(57) =	217.89
	Prob > chi2 =	0.00
	Pseudo R2 =	0.13
	Log likelihood =	-759.18
	Observations =	1488
	Y= Pr(purchase produce) (predict) =	0.7619

Variable	**Coefficients**	**Marginal Effects (dy/dx)**
Age	0.00295	0.000536
Visits	0.166***	0.0302***
Family size	-0.132***	-0.0239***
Education	0.109**	0.0198**
Time to prepare meals	-0.182***	-0.0331***
Food safety concern	0.124	0.0225
Concern for diet/health	0.156*	0.0283*
Environment impact	-0.0971	-0.0176
Agri-enthusiast	0.455***	0.0825***
Presence attributes	-0.154	-0.0280
Convenience attributes	-0.276***	-0.0500***
Spend above average	-0.0454	-0.00824
Income above average	0.240*	0.0440*
Primary shopper	0.313**	0.0594*
CSA	0.302**	0.0542**
Favorite vendor	-0.314**	-0.0585**
Home gardening	0.325**	0.0596**
Female	0.526***	0.0994***
Married	0.591***	0.111***
UT	-0.274*	-0.0493*
Constant	-1.365**	

Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level, respectively.

This discussion focuses only on variables with significant effects. The marginal effects (Table 2) are interpreted as the impact of a unit change in a given variable on the probability that an individual attends a farmers' market to purchase produce. For example, holding all other variables at their means, one extra visit annually to the farmers' market increases the probability of attending a farmers' market primarily to purchase fresh produce by 3%. An additional level of completed education increases attendance by 2%. The predicted probability of visiting a farmers' market for the primary purpose of purchasing produce is 10% greater for a female than for a male, 11% greater for a married person than for a single person, 6% greater for an individual with a home garden than one without, and 6% greater for a primary shopper. Consumers with annual income above the average are 4% more likely to attend in order to purchase fresh produce. On the other hand, the predicted probability of visiting a farmers' market for the primary purpose of purchasing produce is 6% lower for an individual with a favorite vendor and 5% lower for a Utah resident compared to a Nevada counterpart. One additional household member decreases that probability by 2%.

Other Motivations for Farmers' Market Attendance

The MNL model compares a set of four primary motives. Purchasing produce is the reference category, enabling an estimate of the effects of the independent variables on the relative probability that any other motive (ready-to-eat food, social interaction, and packaged foods, arts and crafts) is the primary motivation for attending the farmers' market. The estimated coefficients associated with the MNL model (Table 3) are interpreted relative to the reference category. A positive coefficient indicates that an increase in the variable is associated with an increase in the relative probability of the indicated outcome. For example, increased frequency of farmers' markets visits had a statistically significant negative impact on the probability of attending for social interaction relative to purchasing produce.

Table 3. MNL Model Coefficients Estimates (Purchase Produce as Base Outcome)

		LR chi2(57) =	328.52
		Prob > chi2 =	0.00
		Pseudo R2 =	0.13
		Log likelihood =	-1092.35
		Observations =	1488

	Coefficient Estimates		
Variable	**Ready-to-eat foods**	**Social interaction**	**Packaged foods, arts, & crafts**
Age	-0.00415	-0.00351	-0.00129
Visits	-0.129	-0.276***	0.0410
Family size	-0.00259	0.158***	0.135*
Education	0.0387	-0.0890	-0.239***
Time to prepare meals	0.0608	0.160**	0.318***
Food safety concern	0.0227	-0.114	-0.229*
Concern for diet/health	-0.207	-0.188*	-0.0452
Environment impact	0.0150	0.0745	0.199
Agri-enthusiast	-0.183	-0.457***	-0.582***
Presence attributes	0.0262	0.295**	-0.0937
Convenience attributes	0.147	0.263**	0.389**
Spend above average	-0.348	-0.248	0.923***
Income above average	0.0162	-0.307*	-0.242
Primary shopper	-0.216	-0.326*	-0.259
CSA	-0.967***	-0.111	-0.348
Favorite vendor	0.827***	0.603***	-0.757***
Home gardening	-0.740***	-0.286*	-0.135
Female	-1.065***	-0.530***	-0.199
Married	0.0254	-0.717***	-0.707***
UT	0.248	0.459**	-0.0259
Constant	-0.614	0.660	-0.238

Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level, respectively.

Both farmers' market presence attributes and convenience attributes attract consumers motivated by social interaction as opposed to those who attend to purchase produce. This suggests that consumers whose primary motive is to purchase produce are less concerned about farmers' market attributes such as parking and activities. Furthermore, individuals with home gardens, females, and those willing to join CSAs attend farmers' markets to purchase fresh produce over purchasing ready-to-eat food and social interaction. Married individuals and consumers with strong concerns for food safety attend primarily to purchase produce as opposed to engaging in social interaction or purchasing packaged foods, arts, and crafts. Similarly, agriculture enthusiasts, primary shoppers, and consumers with strong concerns for health and diet are significantly less likely to attend farmers' markets due to social interaction motives, an indication that they are more likely to attend to buy fresh produce.

Farmers' market attributes have relatively strong positive impacts on attending for social interaction reasons, as do family size, having little time to prepare meals at home, having a favorite vendor, and residency in Utah. Improvement in any of these variables reduces the probability of purchasing fresh produce. In addition, as people become busier with work, school, and other activities that interfere with the time available for cooking, they are less likely to purchase produce at farmers' markets, and farmers' markets become an opportunity for social interaction instead. Results also suggest that social interaction motivates significantly more farmers' market attendees in Utah than those in Nevada. The relative probabilities and marginal effects pertaining to each of the four motivations are shown below (Table 4).

Table 4. MNL Model Marginal Effects

Variable	y=Pr(Purchase produce) = 78%	y=Pr(Ready-to-eat foods) = 03%	y=Pr(Social interaction) = 14%	y=Pr(Packaged foods, arts, & crafts) = 05%
	dy/dx	dy/dx	dy/dx	dy/dx
Age	0.000519	-0.000119	-0.000367	-3.27e-05
Visits	0.0297***	-0.00312	-0.0307***	0.00413
Family size	-0.0214***	-0.00102	0.0168***	0.00562
Education	0.0178**	0.00210	-0.00854	-0.0113***
Time to prepare meals	-0.0308***	0.000736	0.0155**	0.0146***
Food safety concern	0.0203	0.00166	-0.0113	-0.0107*
Concern for diet/health	0.0264*	-0.00593	-0.0199*	-0.000604
Environment impact	-0.0161	-0.000188	0.00695	0.00933
Agri-enthusiast	0.0749***	-0.00298	-0.0465***	-0.0255***
Presence attributes	-0.0266	-0.000264	0.0336**	-0.00668
Convenience attributes	-0.0464***	0.00300	0.0262*	0.0172*
Spend above average	-0.00541	-0.0120	-0.0326*	0.0500***
Income above average	0.0410*	0.00234	-0.0333*	-0.0101
Primary shopper	0.0519*	-0.00529	-0.0360	-0.0106
CSA	0.0505**	-0.0300***	-0.00594	-0.0146
Favorite vendor	-0.0636**	0.0292**	0.0732***	-0.0388***
Home gardening	0.0557**	-0.0244**	-0.0280	-0.00332
Female	0.0971***	-0.0381***	-0.0552***	-0.00378
Married	0.107***	0.00547	-0.0802***	-0.0320**
UT	-0.0513**	0.00618	0.0499***	-0.00478
Observations	1,488	1,488	1,488	1,488

Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level, respectively.

The relative probability that an individual attends farmers' markets to purchase produce is 78%. After controlling for all other variables in the model, one additional farmers' market visit per year increases this probability by 3%. One additional level of education increases the probably by 2%. Increased agreement concerning health/diet concerns and supporting local agriculture (agriculture enthusiast) increases this probability by 3% and 8%. In addition, consumers who are willing to join a CSA program are 5% more likely to attend primarily to purchase produce. Compared to singles, married people are 11% more likely to purchase produce. There is a 6% higher chance for consumer with a home garden to attend a farmers' market primarily to purchase produce. Having a favorite vendor and residing in Utah decrease the relative probability of attending farmers' markets for the purpose of purchasing fresh produce by 6% and 5%. Females are 10% more likely than males to purchase fresh produce at a farmers' market. An extra household member decreases the probability by about 2%. An additional level of importance for farmers' markets convenience attributes translates into a 5% fall in the relative probability of attending to purchasing produce.

The relative probability that a person attends farmers' markets primarily for social interaction is 14%. Keeping constant all other variables in the model, an additional household member increases this probability by 2%. A one-increment increase in the importance assigned to either farmers' market convenience or presence attributes equates to an increase of 3% in the relative probability of attending farmers' market for the primary purpose of socializing. Conversely, one more trip to a farmers' market per year decreases the relative likelihood of social interaction by 3%. This probability is 6% and 8% less for females and married individuals. Individuals whose income is above the sample mean and those who spend above the sample average at farmers' markets are both 3% less likely to visit farmers' markets for social interaction.

The relative probability that a person attends farmers' markets primarily to purchase packaged foods, arts, and crafts is 5%. *Ceteris paribus,* having a favorite vendor and being married decreases this probability by 4% and 3%. Similarly, an additional level of agriculture enthusiasm reduces it by 3%. The only consumer characteristics that increase this probability are having little time to prepare meals at home (2%), convenience attributes (2%), and spending above the average at a farmers' market (5%).

Finally, the relative probability that a person attends farmers' markets primarily to buy ready-to-eat foods is only 3%. *Ceteris paribus*, willingness to join a CSA program and home gardening reduce that probability by 3% and 2%, Females have a 4% lower chance of attending farmers' markets primarily to purchase ready-to-eat foods over purchasing produce in comparison with males. Having a favorite vendor increases the relative chances of visiting a farmers' market to buy ready-to-eat food by 3%. These consumers attend the market seeking specific prepared foods or specific vendors.

Fresh Produce Consumers at Farmers' Markets

A cluster analysis was conducted to group respondents who attend farmers' markets primarily to purchase fresh produce (1,086 respondents) into three categories differentiated by the amount they spend on fresh produce at farmers' markets. The analysis followed the partitioning clustering process where the K-Means algorithm minimizes the distance of each point from the center value of the group to which the point belongs. Based on consumer characteristics, the K-mean algorithm initialized a set of cluster centers and assigned each observation in the dataset to the cluster with the nearest center. The process was continued until the centers of the clusters stopped changing. Hence, the clusters contain subjects with a high degree of similarity. This analysis grouped consumers into three clusters—low spenders (312 individuals, 29%), medium spenders (689 individuals, 63%), and high spenders 85 individuals (8%) (see Table 5 for summary stats of characteristics of interest for each group).

Table 5. Characteristics of Fresh Produce Consumers at Farmers' Markets

Consumer Characteristic	**Low Spenders**	**Medium Spenders**	**High Spenders**
	Mean	Mean	Mean
Income	$34,053***	$84,764***	$173,259
Age	39***	45	47
Visits	3.00***	2.73	2.69
Family size	2.401***	2.594*	2.882
Education	4.353**	4.480***	5.235
Time to prepare meals	2.968	2.940	3.129
Food safety concern	4.433**	4.427**	4.635
Concern for diet/health	4.410***	4.424***	4.659
Environment impact	3.603	3.567	3.600
Agri-enthusiast	4.325	4.257	4.265
Presence attributes	3.534	3.497	3.447
Convenient attributes	3.648	3.616	3.618
Spend above average	0.423***	0.502**	0.635
Primary shopper	0.865*	0.824	0.800
CSA	0.506	0.438**	0.565
Favorite vendor	0.353	0.311*	0.412
Home gardening	0.609	0.626	0.659
Female	0.699	0.694	0.682
Married	0.481***	0.730**	0.835
UT	0.625***	0.502	0.471
Observations	312	689	85

Single, double, and triple asterisks (*, **, ***) denote consumer characteristics for which low or medium spenders are significantly different from high spenders (reference cluster) at the 10%, 5%, and 1% levels respectively. The Calinski/Harabsz pseudo–F = 2643.23.

The cluster of high spenders is the smallest; of this group, 84% are married, 80% are the primary shopper, 57% are willing to join a CSA program, 66% have a home garden, and 64% spend above the sample mean. The average annual income for this group is $173,259, about five times more than that of the low spenders group. The average age is forty-seven years. In comparison to the other two clusters, a representative respondent in this group has a four-year college degree as opposed to two-year associate's degree. In addition, the high spenders are significantly more concerned about both food safety and diet or health, perhaps due their larger family size.

The low spenders cluster is the mid-sized group. In comparison to the high spenders, this group consists of younger individuals with lower incomes. The average person in this group is thirty-nine years old, has a two-year associate's degree, and earns $34,053 per year. Farmers' market visits for individuals in this group are significantly higher than those of both high and medium spenders. Among this group, 70% are females, 87% are the primary shopper, 63% are Utahans, 61% are home gardeners, and 51% would join a CSA program. The percentage of low spenders in Utah is significantly higher.

Finally, the medium spenders cluster is the largest. The average person in this group is forty-five years old with a two-year associate's degree and earns $84,764 annually. In this group, 50% spend above sample average, 82% are the primary shopper, 62% are home gardeners, 69% are female, and 73% are married. While most low and high spenders would join CSA programs, only 44% of medium spenders would join.

Similar characteristics across clusters include the proportion of females and those who home garden (statistically the same across the three groups). Consumers of fresh produce at farmers' markets in all clusters are unsure about having time to prepare meals at home. They agree that agricultural open space and supporting local farmers is important to them. The majority of individuals in each of the three clusters do not have a favorite vendor at the farmers' market. Another common trait across clusters is that farmers' market attributes—both presence and convenience—are only somewhat important.

Conclusions

While the literature on direct markets such as farmers' markets is vast, econometric studies of consumer motivations for attending these types of markets are limited. The few existing studies indicate that consumers attend farmers' markets to purchase fresh produce. While some state other motives, little or no analysis is provided. This study uses data collected from a sample of 1,488 farmers' market attendees in Nevada during the 2009 summer season and Utah during the 2011 summer season. The analysis employs two models to assess various motivations for farmers' market attendance above and beyond purchasing local produce. A cluster analysis was performed to examine consumers purchasing fresh produce at farmers' markets in order to investigate target markets for produce vendors.

The primary motivations for farmers' market attendance among sample consumers are to purchase produce (78%), for social interaction (14%), to purchase ready-to-eat foods (5%), and to buy packaged foods, arts, and crafts (3%). The consumer characteristics that significantly increase the probability of attending a farmers' market primarily for purchasing produce are frequency of visits, education level, concerns for diet or health, enthusiasm for agriculture, income above the sample mean, primary shopper, willingness to join a CSA program, home gardening, and married females. Consumer characteristics that significantly diminish the probability of attending a farmers' market primarily for purchasing produce are family size, having little time to prepare meals at home, importance of farmers' market convenience attributes, having a favorite vendor, and being a resident of Utah.

Consumer characteristics that significantly increase the probability of attending a farmers' market primarily for social interaction are family size, having little time to prepare meals at home, importance of both farmers' market presence and convenience attributes, having a favorite vendor, and being a Utah resident. The likelihood of attending a farmers' market primarily to buy packaged foods, arts, and crafts depends significantly on having little time to make meals at home, importance of farmers' market convenience attributes, and spending above the sample average at farmers' markets. The willingness to join CSA program, being a female, and home gardening decrease the relative likelihood of attending a farmers' market primarily to purchase ready-to-eat food.

Results suggest several recommendations for farmers' market managers, local produce vendors, and policy makers. First, focusing on consumers who attend farmers' markets more frequently is a viable marketing strategy to increase sales of fresh produce, especially among Nevada residents. Second, improving farmers' market presence attributes does not induce people to attend farmers' markets for the primary motive of purchasing fresh produce. Instead, it will likely attract more socially oriented individuals. However, this does not undermine the importance of farmers' market attributes like parking, operating hours, recreational facilities, and number of vendors. It simply posits that those consumers who assign high importance to these attributes do not come to the market primarily to purchase produce. Third, marketing strategies aimed at home gardeners, those who are interested in CSA programs, females, and married individuals will lead to an increased number of consumers attending farmers' markets to buy fresh produce. Fourth, enforcing high food safety standards for fresh produce at farmers' markets is an important component of maintaining consumer confidence, especially since those consumers spending more on produce at farmers' markets had strong food safety and diet or health concerns. These consumers were also older, married, highly educated, and with incomes above the sample average.

This study examines a variety of consumer motivations for attending farmers' markets. In addition to findings from previous studies—which suggest that farmers' markets attract fresh produce customers—this study indicates that social interaction; buying packaged foods, arts, and crafts; and buying ready-to-eat food are other motivations. This study identifies consumer characteristics, attitudes, and concerns that explain relative probabilities of attending for all four motivations. Consequently, the study contributes to the existing literature by providing useful information to vendors and market managers in their efforts to meet attendee expectations.

This study has some limitations. First, it analyzes consumers by primary farmers' market attendance motivations and doesn't consider secondary motivations. Another limitation is geographic, as the study examines farmers' markets only in Nevada and Utah. However, the findings are likely applicable to other locations with farmers' markets with similar characteristics and products. Findings from this study obviously could be used to compare consumer motivations across regions. Finally, in an effort to minimize the differences among the farmers' markets under consideration, the study uses data from farmers' markets with similar characteristics. However, market size and variety of vendors in terms of product types were not recorded.

Subsequent studies might consider using rank-ordered outcomes to investigate both primary and secondary motives for consumer attendance. Examining the motivations of consumers who don't attend farmers' markets and evaluating how vendors and market managers might overcome their concerns would also be of interest. Future studies could also assess consumer willingness to pay for farmers' market attributes such as family and child activities, music and other events, or facilities and parking, especially among those who attend farmers' market primarily for social interaction.

Acknowledgements

This research was supported by the Utah Agricultural Experiment Station, Utah State University, and approved as journal paper number 8562. The authors would like to thank four anonymous reviewers and the managing editor for their helpful comments and suggestions.

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International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Reducing Hold-up Risks in Ethanol Supply Chains: A Transaction Cost Perspective

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Abstract

Ethanol plants sit at the intersection of three main supply chains, involving the procurement of feedstocks and the marketing of ethanol and distillers grains. A transaction cost framework assesses the extent to which uncertainty, asset specificity, and transaction frequency create incentives for opportunistic behavior by exchange partners leading to problems of hold-up. Using case study evidence from the western Canadian ethanol sector, solutions to the hold-up risks facing ethanol plants are explored. Contracting and integration feature strongly in downstream output markets. The positioning of the ethanol enterprise within a firm's overall business model, whether as a stand-alone investment or as a forward or backward integration strategy, is an important consideration for future supply chain research in this sector.

Keywords: vertical coordination, opportunism, asset specificity, distillers grains, feedstocks.

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Introduction

The biofuel sector in many countries has undergone rapid development over the past decade, with ethanol, in particular, emerging as a major biofuel in the U.S. and Canada. While public sector subsidization or market interventions in the form of blending mandates frequently played a role in encouraging initial investments in the sector, the long-run commercial viability of ethanol production (with or without continued public sector support) depends on the ability to access an inexpensive and reliable supply of inputs, as well as finding stable markets for ethanol and its co-products. The structure of supply chain relationships in the ethanol sector affects the security and stability of critical input supplies, as well as the stability of output markets for an ethanol plant, and is the focus of this paper.

A unique feature of ethanol plants is their position at the intersection of multiple supply chains which result in the production of grain products, livestock, and fuel (blended gasoline). The primary feedstock, at least for first generation ethanol production, is cereal grain (usually corn or wheat), while output from ethanol plants includes not only ethanol for fuel, but also co-products used in livestock feeding. Managers of ethanol plants must therefore coordinate supply chain relationships within three quite distinct sectors, facing different market conditions and sources of risk. Of interest therefore is the source and incidence of transaction costs that underpin the relationships, and the strategies which incumbent firms have taken to mitigate these transaction costs. Indeed, a striking feature of the North American ethanol sector is the existence of an array of governance mechanisms within input and output supply chains, from spot market transactions, to contracts, and vertical integration.

Transaction Cost Economics (TCE) (Coase 1937; Cheung 1969; Williamson 1979, 1985, 2002; North 1984) offers rich insights into the organization of economic transactions and the structure of supply chains. The approach has been applied extensively to numerous aspects of agri-food supply chains (see for example, Sporleder 1992; Hobbs 1997; Fearne 1998; Hobbs and Young 2000; Boger 2001; Ménard and Valceschini 2005), but there are few examples of its application to ethanol production and supply chains. Recent studies by Altman et al. (2007) and Altman and Johnson (2008) examine transaction costs broadly within the US “biopower” industry, and make a strong case for the use of a transaction cost approach to examine organizational structures in the emerging bioenergy sectors, although their analyses do not focus solely on ethanol. Applying a transaction cost lens to the ethanol sector provides an opportunity to explore, at a micro-analytical level, the factors driving the governance structures of supply chains in the sector and a lens through which to examine the juxtaposition of the multiple supply chain relationships that characterize the business environment for an ethanol plant. A particular focus of the analysis in this paper is the identification of contractual hazards, opportunism and uncertainty within these supply chain relationships. A case study analysis of three ethanol plants characterized by very different approaches to supply chain governance is provided. This paper addresses a research gap in the bioenergy economics literature by bringing an economics of governance lens to the bioenergy sector.

Following the introduction, an overview of the Canadian ethanol sector and its primary supply chains is presented. Insights from the TCE literature are then used to outline the expected relationships between transaction characteristics, transaction costs and governance outcomes in a conceptual model. Applying this frame to the ethanol sector, the transaction characteristics that influence transaction costs in the input and output supply chain relationships facing ethanol plants are identified, along with an assessment of the threat of opportunism and hold-up in each case. Supply chain governance structures that reduce these transaction costs and mitigate hold-up risks are then assessed, using case study evidence from the ethanol sector in western Canada. The paper concludes with a discussion of the implications of the analysis for business management scholars and suggestions for further research.

The Canadian Ethanol Sector

A standard North American first generation ethanol plant uses wheat or corn as its primary feedstock and produces ethanol, as well as co-products in the form of wet or dried distillers grains (WDGs/DDGs) for livestock feed. Ethanol producers typically purchase grain feedstocks directly from grain producers or from a grain company. Canada's feedstock grains are produced primarily in the grain belt of the Prairie provinces of Alberta, Saskatchewan and Manitoba (wheat) and in the provinces of Ontario and Quebec (corn). First-generation ethanol plants (i.e. those using grain feedstocks), are primarily located in those areas[1]. In 2010 there were seven ethanol plants in Ontario, one in Quebec, and eight in the Prairie provinces (five of which are in Saskatchewan) (Canadian Renewal Fuels Association, 2013). Depending on the cost and availability of local feedstocks, some ethanol producers also import corn from the US to maintain their ethanol stream. Total ethanol production capacity (operational and under construction) in Canada in 2010 was approximately 2 billion litres, with approximately 78% generated from corn feedstocks and 30% from wheat (Canadian Renewable Fuels Association, 2013)[2].

On the output side, the primary products of ethanol production are ethanol and either wet or dried distillers grains (although DDGs are far more common). Increasingly, there are other co-products resulting from ethanol production but these typically represent a small percentage of ethanol plant revenue and are therefore not considered here. Once ethanol is produced, it is blended with gasoline at various percentages and sold to consumers. Fuel blenders/refiners are major purchasers of ethanol. The Canadian fuel blending/refining sector is highly concentrated, with only three companies operating nationally (Imperial Oil, Shell and Petro-Canada), and a further nine companies operating primarily on a regional basis, usually with one refinery each. The three national companies have refineries located either close to oil production (e.g. Alberta) or in areas where gasoline consumption is high due to density of population (e.g. southern Quebec and southern Ontario). Ethanol producers are therefore dealing with an oligopolistic fuel blending industry. The effect of significant industry concentration is exacerbated by the high cost

[1] Second-generation ethanol production, which uses organic wastes as fuel, is a relatively minor contributor to Canadian ethanol supply at the present time. Three second-generation plants either operating or under construction, using straw, wood waste and municipal landfill waste, together account for only around 2.5% of total feedstock volume in Canada. Consideration of the supply chain relationships for second-generation ethanol plants is beyond the scope of the present paper, and represents a fruitful area for further research, in particular, the extent to which holds-up exist which impede more extensive investment in the commercialization of second generation ethanol technologies.

[2] As two Canadian ethanol plants are able to use either corn or wheat feedstocks, the percentages do not sum to 100.

of transporting ethanol which requires an entirely separate transportation and storage system from gasoline until blending takes place (Natural Resources Canada, 2008). The conventional petroleum transportation system (pipelines) contains water which causes ethanol to separate from gasoline and become unusable as fuel. As a result, the blending of ethanol with gasoline typically occurs close to the final point of distribution.

Distillers grains (either wet or dried) are sold to livestock producers and used in high-protein feed rations. Beef and dairy cattle operations are the primary purchasers of distillers grains, although hogs and poultry can also use dried distillers grains (DDGs) to a lesser extent in feed rations. Wet distillers grains (WDGs) have a short shelf life and are costly to transport, and consequently are usually only sold to beef feedlots in close proximity to the ethanol plant. Drying distillers grains improves the nutrient concentration and reduces transportation costs, but also requires drying capacity and increases energy usage, resulting in higher utility costs. Dried distillers grains can be marketed over a larger geographic area relative to the wet counterpart and most ethanol plants dry their distillers grains and sell the product regionally. Nevertheless, transportation and storage costs are not insignificant and ethanol plants situated in more concentrated livestock production areas will be at an advantage in this regard.

From the above discussion it is clear that the Canadian ethanol sector sits at the intersection of three main supply chains: feed grains, gasoline, and livestock production. The major participants and supply chain transactions in the ethanol sector are summarized in Figure 1, which is a stylized representation of ethanol supply chain relationships focusing on the key transactions[3]. Including the ethanol plant, there are four major supply chain participants, each engaging in separate transactions (T1-T3) with the ethanol plant. The analysis that follows identifies characteristics in each supply chain relationship that can increase transaction costs, potentially leading to a hold-up problem in which exchange may not occur or becomes more costly. The paper explores three main research questions: (i) what are the sources of opportunism and potential hold-up in ethanol supply chains; (ii) how are these potential hold-ups expected to affect transactions costs in ethanol supply chains; and (iii) what supply chain governance strategies are in use to mitigate hold-up risks? The paper builds upon an existing body of literature examining governance structures within vertical supply chains (see for example, Zylbersztajn and Farina, 1999; Hobbs and Young, 2000; Raynaud et al., 2005). The next section outlines insights from the TCE literature that inform the conceptual framework used in the case study analysis.

[3] In a similar approach, Raynaud et al. (2005) analyses governance mechanisms in European agri-food supply chains as a series of transactions.

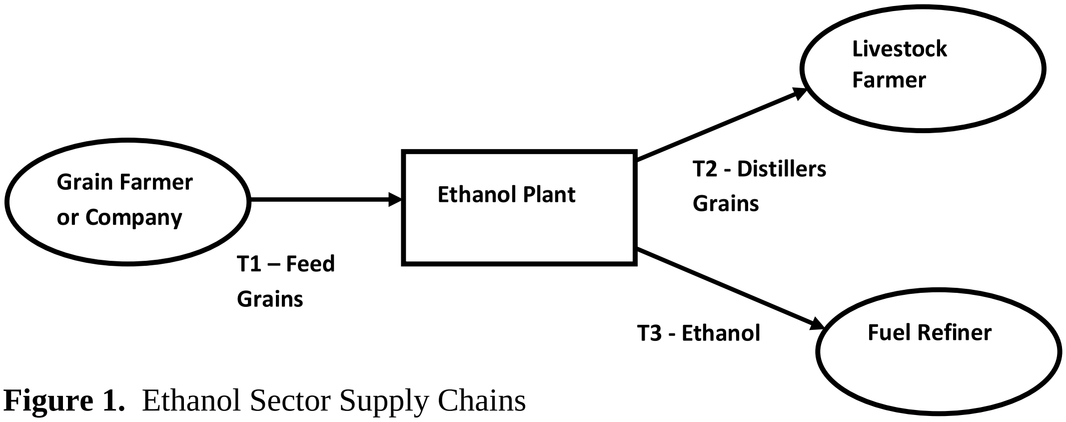

Figure 1. Ethanol Sector Supply Chains

Sources and Outcomes of Transaction Costs

The TCE literature has its roots in the original insights by Coase (1937) that transactions do not occur in a frictionless economic environment: there are costs to carrying out transactions and these costs influence whether transactions occur within a firm or across a market interface. Transaction costs include the costs associated with activities carried out in preparation for, and after, an exchange. Transaction costs arise both prior to an exchange (*ex ante*), and after an exchange has occurred (*ex post*). *Ex ante* transaction costs, often referred to as "search costs" and "negotiation costs", are incurred in an effort to obtain the best possible terms of exchange with a trading partner and include the costs of searching for an appropriate exchange (prices, exchange partners, etc.), in addition to drafting and negotiating an exchange agreement. *Ex post* transaction costs, often referred to as "monitoring and enforcement costs", are incurred after an exchange has been completed and are associated with ensuring that the terms of a contract are honored, and in seeking recourse in the event of breach of contract or maladaptation of exchange terms (Hobbs, 1997).

According to Williamson (1979, 2005), the governance structure that emerges will be the organizational form which minimizes the sum of production and transaction costs. In particular, he argues that the comparative efficiency of alternative modes of governance depend on the attributes or characteristics of the transaction, thereby allowing the development of testable hypotheses or predictive assertions linking transaction characteristics to expected governance outcomes. These core insights have provided a rich basis on which to examine the use of spot markets, contracts, vertical integration, alliances, and other inter-firm relationships to govern transactions.

Two behavioral assumptions underpin the transaction cost approach: *bounded rationality* and *opportunism. Bounded rationality* recognizes that although individuals and firms intend to make rational decisions, they are limited in doing so by their cognitive abilities (Simon, 1961). It is not physically possible to evaluate all potential outcomes of a particular decision. *Opportunism* is defined by Williamson (1979) as self-interest seeking with guile. Vulnerability to opportunistic behavior increases in the presence of small numbers bargaining where there are few alternative suppliers of key inputs or buyers of outputs.

A rich literature has emerged expanding upon the determinants and outcomes of transaction costs in the context of the opportunism problem. Dahlstrom and Ngaard (1999) present a theoretical model that frames opportunism as a determinant of transaction costs and examines control structures that alleviate opportunism. In their model, interfirm cooperation and formalization of contractual relationships influence the prevalence of opportunistic behavior, while firms incur bargaining (negotiation) costs, monitoring, enforcement and maladaptation costs in mitigating the effects of or controlling opportunism. Thus, opportunism leads to transaction costs. Similarly, Jap and Anderson (2003) discuss how a number of relationship safeguards are used to mitigate opportunistic behavior, including incentive structures and contractual provisions, monitoring, reputation, norms and trust. In an analysis of franchisor-franchisee relationships, Wathne and Heide (2000) distinguish between blatant or strong-form opportunism and passive opportunism, arguing that these arise differently depending on the exchange context – whether a new or existing relationship. Examples of strong-form or blatant opportunism include deliberate misrepresentation or abrogation of contract terms, while passive opportunism arises from a failure to act, such as failures to disclose information or refusals to adapt. Vulnerability to opportunism is therefore a key driver of transaction costs and governance outcomes.

In his original work, Williamson (1979) identifies three transaction characteristics that influence governance outcomes in the presence of opportunism and bounded rationality, namely uncertainty, asset specificity, and frequency. *Asset specificity* occurs when assets are specific to an exchange with little or no value in an alternative use or to an alternative user (Klein et al., 1978). Asset specificity takes a number of forms, including site specificity, physical asset specificity, dedicated assets, human capital specificity and time specificity (Williamson, 1985). Site specificity occurs when assets are specific to a certain location and are highly immobile, thereby rendering the holder of the asset vulnerable to opportunistic recontracting. Physical asset specificity arises when assets possess physical characteristics that are specific to a certain transaction and have little value in alternative uses. Dedicated assets are created when a transaction-specific investment is made in anticipation of selling a significant amount of product resulting from that investment to a specific customer. Human asset specificity refers to investments in knowledge or a skill that is specific to an exchange relationship. Time specificity is related to the perishability of the asset or time sensitivity of the transaction which leaves one party vulnerable to opportunistic recontracting by an exchange partner.

Once a specific asset is committed to an exchange, the owner of the asset is vulnerable to opportunistic behavior by the exchange partner in attempting to renegotiate the terms of the exchange to appropriate rents from the specific asset, which is now a sunk cost. The threat of re-negotiation if a specific investment is made can prevent an exchange from occurring altogether. This is a source of ex ante “hold-up”.

Increased asset specificity usually results in more formal governance structures to guard against the risk of opportunism. Williamson (2002) presents a contracting schema that differentiates between components produced by non-specific “general purpose” technology and components produced using highly-specific “special purpose” technology. General purpose technology requires no safeguards and is exchanged in the spot market. As the specificity of technology increases, so too must the level of safeguards necessary to ensure that a successful transaction occurs. In some cases, contracting alone can provide adequate safeguards, while in cases of extreme specificity, safeguards will approach their limit, and "unified ownership" or complete vertical integration becomes the transaction-cost efficient method of governance. To a large extent, asset specificity has been the primary focus of much of the subsequent TCE literature.

Ceteris paribus, increased *uncertainty* will lead to closer vertical coordination, as reducing uncertainty through increased coordination typically costs less than dealing with opportunism resulting from the uncertainty. If firms were certain that they could predict the actions of those with whom they exchange, the effects of bounded rationality, opportunism, and asset specificity could be avoided by safeguarding input and output contracts with preventative clauses or by choosing to deal only with individuals whose *ex post* behavior is known to be desirable. Many sources of uncertainty exist and can be broadly categorized as environmental (or external) uncertainty and behavioral (or internal) uncertainty (Robertson and Gatingnon 1988; Walker and Weber 1984). Environmental uncertainty includes both demand and supply (volume) uncertainty, leading to uncertainty over prices, as well as technological uncertainty. Behavioral uncertainty arises with respect to the actions of key transaction partners or in assessing the performance of the business relationship with suppliers or buyers[4]. Uncertainty is closely related to contract incompleteness: in the absence of uncertainty, buyers or sellers can specify all relevant contingencies in an enforceable contract. Conversely, uncertainty over the price and/or supply of inputs, the price of outputs or the actions of transaction partners increases the transaction costs of drawing up and enforcing contractual agreements.

The effect of *frequency* on vertical coordination is ambiguous. On the one hand it can be argued that highly frequent transactions will occur through spot markets because the necessity of repeated exchanges and the value of reputation create natural incentives against acting opportunistically to jeopardize future transactions. According to this logic, as transactions between individuals become less frequent, the incentive for opportunistic behavior increases. An alternative view holds that frequently occurring transactions lend themselves to more closely coordinated governance structures because the familiarity and trust developed though repeated exchange can facilitate the development of more formal relationships, and highly frequent transactions allow investments in transaction-specific infrastructure to be internalized. An assessment of the effect of the frequency of transactions on vertical coordination outcomes must therefore be taken in the context of the other two transaction characteristics: uncertainty and asset specificity, which are the primary drivers of transaction costs.

A related point is the role of trust in reducing transaction costs. Williamson (1993) observes that trust is an elusive concept, with many meanings, and argues (controversially) that most business relationships characterized as trust-based relationships have other explanations, such as a self-

[4] In an analysis of the classic "make or buy" decision, Walker and Weber (1984) focus on two types of external uncertainty: volume uncertainty and technological uncertainty. The authors argue that volume uncertainty creates unexpected production costs or unexpected excess capacity for suppliers and stock-outs or excess inventory for buyers. Volume uncertainty is hypothesized to lead to a "make" rather than a "buy" decision. As Robertson and Gatignon (1998) point out, the effect of technological uncertainty is less clear: while some studies hypothesize that technological uncertainty increases the costs of recontracting, thereby favoring vertical integration, other researchers have found the opposite relationship, whereby flexible organizational structures are better able to respond quickly to a changing technological environment (Robertson and Gatignon, 1988)

enforcing institutional environment—including the presence of social network or community reputation effects that penalize opportunistic behavior—or differences in risk attitudes, knowledge and experience. Other authors, however, have argued that trust and trust-based relationships exist, and a considerable literature has emerged exploring the role of trust in the development of sustainable supply chain relationships (see for example, Fischer et al. 2009; Morgan and Hunt 1994). Gulati (1995) examines the emergence of interfirm trust from repeated alliances between the same firms, arguing that experience engenders trust among partners and trust reduces the transaction costs of their future alliance relationships. Trust therefore reduces behavioral uncertainty.

To summarize, asset specificity, uncertainty, frequency and opportunism are core concepts underpinning the TCE literature. Figure 2 maps out the relationships between these concepts and is the basis of the transaction cost analysis of ethanol supply chains used in this paper. Thus, the extent to which asset specific investments are required, the degree of environmental and behavioral uncertainty within which a transaction is conducted, and the frequency of transactions influence the threat of opportunism and risk of hold-up. Ex ante and ex post transaction costs are incurred in an attempt to mitigate the threat of opportunism, and determine the relative efficiency of different governance outcomes, whether spot markets, hybrids, or vertical integration. If effective, these governance outcomes mitigate vulnerability to opportunism and reduce transaction costs, as shown by the feedback arrows in Figure 2. The next section identifies the transaction characteristics and sources of hold-up in ethanol supply chains.

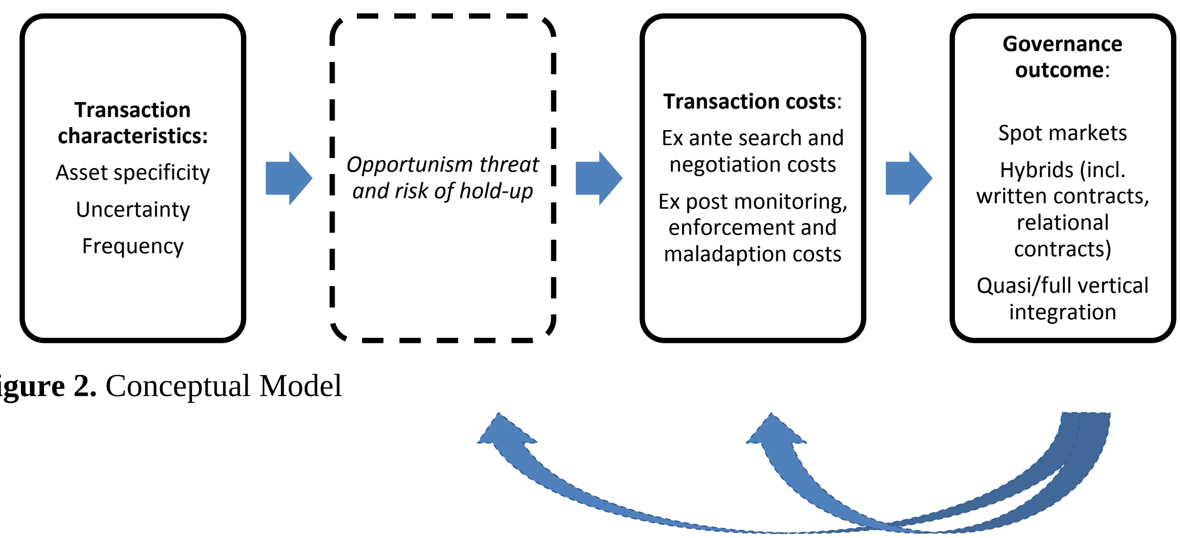

Figure 2. Conceptual Model

Transaction Characteristics and Hold-ups in Ethanol Supply Chains

The transaction cost analysis of ethanol supply chains presented below examines the supply chain relationships illustrated in Figure 1 in the context of the conceptual model presented in Figure 2. An assessment of the degree of asset specificity, uncertainty, and transaction frequency at each supply chain interaction is used to identify potential sources of transaction costs and the extent to which ethanol plants are vulnerable to opportunistic behavior by their exchange partners. This allows inferences as to the types of governance structures that are expected to reduce transaction costs.

In each relationship, it can be assumed that bounded rationality is endemic: it exists for both parties. For example, managers of an ethanol plant face bounded rationality in determining input prices for feedstocks: establishing long-term supply agreements at fixed prices only to have unforeseen events reduce the spot price of those inputs over the length of the agreement. Similar environmental uncertainties exist at the ethanol plant-fuel refiner interface.

The ethanol plant infrastructure represents a highly specific investment with few alternative uses and often, due to small numbers bargaining, few alternative users (buyers) of ethanol. In the absence of appropriate governance structures to mitigate the effects of asset specificity on transaction costs, ethanol plants are at risk of opportunism in both input and output exchanges. The plant is physically specific because it has little value in alternative uses and is site specific because its location relative to its source of inputs as well as its output markets is important. In particular, wet distillers grains suffer from a degree of time specificity since their quality deteriorates rapidly if they are not sold and consumed relatively quickly. The presence of physical asset specificity for the ethanol operator suggests that there is at least some threat of opportunism in each of its supply chain relationships.

Potential opportunistic behavior includes grain producers reneging upon a prior agreement to deliver grain feedstocks to an ethanol plant at an agreed upon price and delivery schedule due to unexpectedly higher spot prices, or a gasoline blender reneging upon a commitment to source ethanol from an ethanol plant at a pre-agreed price. In the presence of information asymmetry, bounded rationality and opportunism result in more complex transactions and increase the vulnerability of exchange partners to a break-down in the exchange relationship. Transaction costs are incurred in reducing exposure to this vulnerability. *Ex ante* transaction costs arise in the identification of a consistent and reliable source of inputs (e.g. feedstocks), or in negotiating forward contracts or supply agreements with grain producers. Examples of *ex post* transaction costs include ensuring that grain is delivered to the ethanol plant in accordance with delivery commitments, or that blenders accept delivery of ethanol at pre-agreed terms, and in seeking recourse in the event that suppliers (buyers) renege upon delivery (purchase) commitments. The remainder of this section explores the transaction characteristics that lead to hold-up risks and transaction costs in the context of the three supply chains relationships for ethanol plants.

Relationship One: Grain Farmer/Company and Ethanol Plant (T1)

The first relationship of interest is between the ethanol plant and its primary input providers: grain producers or grain companies (T1 in Figure 1). The ethanol plant must ensure that it has a consistent supply of either corn or wheat (or in some cases both) delivered on demand throughout the year. In a survey of the procurement and marketing practices of 60 U.S. ethanol producers, Schmidgall et al. (2010) report that the vast majority (73%) of plants are limited to one type of feedstock, and for the most part this is also true of the Canadian ethanol sector. Although the ethanol plant represents a specific asset, grain is a non-specific asset and therefore has numerous alternative uses (or markets). This means that grain producers or grain companies would not necessarily have to sell their grain to the ethanol plant, thus providing little incentive for opportunistic behavior on the part of the ethanol plant. Similarly, given the large number of potential grain producers with whom to transact, the consequences of any individual grain producer acting opportunistically against the ethanol plant is unlikely to be significant because the plant can simply purchase grain from a different farmer. Of course, the consequences of widespread opportunism by suppliers of feedstock grains in response to higher spot prices are more severe[5]. In this regard, it can be concluded that the degree of asset specificity is dependent on the existence of small numbers bargaining, which can differ by region depending on the existence of an active spot market in feedstocks[6]. Moreover, a region with relatively diverse agriculture, that is, with both grain producers and livestock producers or mixed-farming operations, would tend to reduce the asset-specific nature of the feedstock grain still further.

Turning to transaction frequency, ethanol plants have repeated transactions with farmers and/or grain companies located near the ethanol plant, as both parties benefit from reducing transportation costs associated with delivery. The incentive for ethanol producers to transact with a grain company or perhaps a large producer group (e.g. a cooperative) rather than with individual farmers may be higher, since this enables the ethanol plant to reduce the number of separate transactions required to obtain the large quantities of grain that it needs on a regular basis. Regardless of whether purchases are made from grain companies or individual farmers, repeated transactions build trust and provide a disincentive for opportunistic behavior because this would jeopardize future transactions. In this regard, transaction frequency should mitigate the incentive for opportunistic behavior, lowering transaction costs and allowing looser forms of coordination. In a spot market situation, monitoring and enforcement costs are expected to be low for the ethanol operator, since once an agreement is reached, physical possession of the grain can be taken. On the other hand, if an agreement for purchase is reached in advance, monitoring and enforcement costs are incurred in ensuring that delivery occurs in a timely manner. In such cases, the ethanol plant will have an incentive to seek closer vertical coordination with its grain suppliers.

In the context of uncertainty, the price and supply of feed grains are relevant for both grain feedstock suppliers and ethanol plant operators. As grain prices are influenced by developments in the ethanol industry, the livestock sector, and in the grain farming industry, forecasting supply volumes and therefore long run prices is fraught with uncertainty, and there is evidence that ethanol plants regard input costs and securing predictable feedstock supplies as some of the most challenging aspects of their business (Schmidgall et al. 2010). Given the need for cost and revenue stability, this uncertainty should provide a strong incentive for ethanol plants to form closer relationships with grain producers so that delivery volumes and prices can be agreed upon well in advance of delivery, for example, through forward contracting.

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[5] At the time their survey was conducted, Schmidgall et al. (2010) report little concern among U.S. ethanol plants with respect to the availability of feedstocks, however, the extent to which this has remained the case given price volatility in the grains sector since 2008 remains to be seen.

[6] An active grain market will offer a variety of options for grain farmers. Some grains can be marketed to millers or their agents as lower-quality milling grains rather than as an ethanol feedstock. Even grains that are indisputably of feedstock quality can be marketed directly to livestock producers, either under contract or on the spot market (depending of course on the livestock producer's access to alternative supplies, and the price thereof).

Overall, several transaction characteristics play a role in determining the type of governance structure that exists in the relationship between ethanol producers and grain suppliers, and have counter-acting effects. On the one hand, recurring transactions between the same firms may increase transaction costs due to the potential for opportunistic behavior if the relationship is perceived as a “captive” market. If through repeated transactions trust is established, however, transaction costs will be lower and the risk of hold-up declines. Rather than asset specificity, which is medium-to-low in this relationship, uncertainty is likely to be the stronger determinant of the governance structure that emerges. There exists ongoing uncertainty associated with grain volumes and prices, be it due to weather-induced forage deficiencies in the livestock sector or weather-induced differences in crop quality in the grain sector. Either situation, in the short term, would increase the risk associated with spot market transactions, and thus provide an impetus toward forward contracting as a safeguard against this risk. In the current environment of volatile grain prices, the prospect of increased transaction costs seems likely to provide an added incentive for closer vertical coordination on behalf of both parties.

Relationship Two: Ethanol Producers and Livestock Farmers (T2)

Distillers grains account for between 10% and 20% of total revenue generated from ethanol production and often determine whether or not an ethanol plant is profitable. Distillers grains are a highly specific asset and therefore place the ethanol plant at risk of opportunistic behavior by buyers (livestock farmers). The specificity of distillers grains occurs in several forms, including time specificity, physical asset specificity, and in some cases, dedicated specificity. Time specificity occurs because distillers grains in their original wet form are perishable and expensive to transport long distances. For this reason, WDGs tend to transported over distances of less than 200km prior to being consumed by livestock. The short storage life and high water content of WDGs makes this specificity larger than is the case with DDGs, which can be transported longer distances and have a much longer storage life (ranging from 40 days up to a year). Physical asset specificity occurs in distillers grains because they have little value in uses other than as livestock feed. In cases where an agreement is made in advance of ethanol production, distillers grains become dedicated assets because there is anticipation that they will be sold to a specific customer. Given the abundance of asset-specific characteristics inherent in WDGs in particular, it can be expected that the threat of opportunism is likely to lead to closer supply chain coordination through forward contracting or vertical integration between an ethanol plant and livestock feeding operations.

The threat of opportunistic behavior by buyers of distillers grains is exacerbated by the oversupply of these grains resulting from rapid expansion in ethanol plant capacity. Current and projected ethanol production across North America is estimated at almost 60 billion litres[7] (Nebraska Energy Office 2013; Canadian Renewable Fuels Association 2013). The WDGs resulting from a 12.5 million litre ethanol plant operated by Pound-Maker Agventures in Saskatchewan, for example, provides protein rations for between 36,000 and 48,000 head of cattle annually in the company’s adjacent feedlot (Pound-Maker Annual Report 2012). Applying this ratio to total US and Canadian ethanol capacity, 60 billion litres would produce enough

[7] Approximately 16 billion U.S. gallons

distillers grains to feed around 170 to 225 million head of cattle annually. As of January 2012, the total cattle herd in the US and Canada was estimated to be approximately 103 million including calves (ERS 2013), by no means all of which have ready access to distillers grains as a food supplement. Further exacerbating this situation are the ethanol mandates in the US requiring that ethanol and biodiesel production reach 136 billion litres by 2022.

The expanding supply of distillers grains also creates substantial price and therefore revenue uncertainty regarding this co-product. Predicting prices in the long run requires information related to the rate of ethanol expansion, and the mobility and transportation patterns of these grains, as well as the availability of substitutes. These environmental uncertainties further enhance the incentives for increased vertical coordination between ethanol producers and livestock producers.

A final relevant characteristic of the exchange of distillers grains is the high frequency of transactions between ethanol plants and livestock producers. As the ethanol industry in Canada is relatively concentrated, and individual ethanol producers can benefit from relationships with large feedlot operators (which are common in Alberta and parts of Saskatchewan) who can purchase large quantities of distillers grains, the probability of engaging in repeated transactions with the same firm is increased. Repeated transactions build trust. As is the case with feedstock grains, this reduces the risk of opportunistic behavior given the importance of reputation in sustaining ongoing business relationships. Nevertheless, these relationships could evolve into closer coordination in order to minimize some of the uncertainties discussed above.

Relationship Three: Ethanol Producers and Ethanol Blenders (T3)

Since ethanol is the primary product and generates approximately 80% of total revenue for ethanol plants, reducing transaction costs and minimizing the threat of hold-up in marketing ethanol are important considerations for ethanol producers. Similarly, the obligation of having to fulfill ethanol mandates provides an incentive for fuel blenders to formalize their relationship with ethanol plants[8].

Ethanol production has asset specific characteristics that create vulnerability to opportunistic behavior. First, it is site specific because ethanol can only be transported by truck or rail (as opposed to pipeline) and is expensive to transport long distances. It is physically specific because, although it is used for other purposes, in the large quantities in which it is produced its value in these uses is greatly reduced. Finally, it is a dedicated asset in cases where it is expected that the ethanol will be sold to a specific customer. In a highly concentrated gasoline refining industry the probability of this is high. This relatively high degree of asset specificity provides an incentive for the establishment of a closely coordinated relationship with gasoline-ethanol blenders.

[8] Ethanol blending mandates (proposed or in place) in Canada include a 5% Federal mandate, together with provincial blending mandates ranging from 5% (British Columbia and Ontario) to 7.5% (Saskatchewan) and 8.5% (Manitoba) (Auld 2008)

The risk of hold-up arising from the asset specificity of ethanol plants depends on the extent to which ethanol mandates have been fulfilled. Blending ethanol with gasoline represents an additional cost for fuel blenders and will only occur until mandates are met. Finding markets for ethanol produced beyond the existing blending mandates is likely to be challenging. Current ethanol production in Canada has not yet exceeded federal mandates but may do so in the not-too-distant future. Provincial mandates will also factor into the equation for similar reasons and will increase the threat of opportunistic behavior by fuel blenders. Ethanol plants are particularly vulnerable to policy reversals with respect to the existence and level of blending mandates, which adds an intriguing political economy dimension to the uncertainty faced by these firms[9].

Uncertainty associated with input prices in both industries is a strong incentive for closer supply chain coordination for both ethanol producers and blenders. For ethanol producers, there is uncertainty with respect to the supply and price of feedstock grains and, to a lesser extent, the price of utilities. For blenders, the uncertainty is related to the price of oil and to a lesser extent the price of ethanol, which factor into demand uncertainty. In this regard, both parties benefit by negotiating a long-term price for ethanol. With more certainty about the demand for and price of this key output, ethanol plants are better able to determine the level of feedstock grain (input) prices that they can establish with grain producers and are better able to forecast their feedstock demands. This represents a further incentive for ethanol plants to seek closer vertical coordination with fuel blenders, rather than relying purely on the spot market to sell ethanol.

A final characteristic of the relationship between ethanol producers and blenders that affects governance outcomes is the frequency with which these transactions occur. The relatively high degree of concentration that exists in both the ethanol production and blending industries suggests that transactions between firms are highly frequent. As is the case in each of the other relationships discussed, this has ambiguous implications for the vertical coordination outcome. Consequently, reducing price uncertainty as well as securing a stable market for the product are expected to be the main determinants of the governance structures that emerge.

In summary, several transaction characteristics influence the degree of vertical coordination in each of the relationships described above and are considered within the context of the conceptual framework outlined in Figure 2. Table 1 summarizes the transaction characteristics for the three major supply chain relationships. Transaction costs and the threat of opportunism associated with these characteristics are posited as low, medium, and high. In each case we assume that there exists some bounded rationality and that an ethanol plant represents an asset specific investment, thereby exacerbating the vulnerability of ethanol producers to opportunistic behavior by trading partners. The governance outcomes that are expected to arise as a result of the threat of hold-up are also indicated in the table.

For transactions involving feedstock grains used for ethanol production, Table 1 suggests that the threat of opportunistic behavior and the resulting degree of vertical coordination is medium to low. While complete vertical integration is unlikely, neither is relying solely on spot market

[9] Interestingly, Schmidgall (2010) find that ‘government policy’ was the second most important challenge identified by U.S. ethanol producers (after input costs).

transactions, therefore marketing contracts or another form of hybrid relationship is expected to characterize the relationship between ethanol plants and grain producers, with spot markets providing residual supplies of grain. The high level of uncertainty associated with grain prices/supply drive this relationship. In transactions involving the exchange of primary and secondary outputs, ethanol and distillers grains respectively, the threat of opportunism is high, arising from both the short run price/supply uncertainties associated with these products and from physical characteristics that make them specific to the particular relationship. The high frequency of transactions in each relationship, coupled with price volatility, strengthens the case for closer vertical coordination in the form of long-term contracts, quasi or full integration (hierarchy). The following section examines in more detail the type of governance structures that mitigate opportunism risks and facilitate a reduction in transaction costs, drawing upon case study evidence from the ethanol sector in western Canada.

Table 1. Transaction Characteristics and Governance Outcomes in Ethanol Supply Chains

	Transaction Characteristics			**Hold-Ups and Governance Outcomes**	
Relationship S=Seller; B=Buyer	*Supply/Demand Price Uncertainty*	*Transaction Frequency*	*Asset Specific Investment*	*Opportunistic Threat*	*Vertical Coordination*
Ethanol Inputs ***Transaction 1 (Feedgrains)*** Feed (S) Ethanol Producer (B)	High	High	-No	Medium/Low	Mixed: Spot markets, marketing contracts
Ethanol Outputs ***Transaction 2 (DDGs/WDGS)*** Ethanol Producer (S) Livestock Producer (B)	High	High	-Yes	High	Hybrids & Hierarchy: Contracts & integration
Transaction 3 (Ethanol) Ethanol Producer (S) Ethanol Blender (B)	High	High	-Yes	High	Hybrids & Hierarchy: Contracts & integration

Mitigating Hold-Up Risks: Case Study Evidence of Governance Outcomes

Having identified relationships along the ethanol supply chain where the risk of opportunistic behavior exists, this section discusses governance structures that can ameliorate this risk, thereby reducing transaction costs. Potential solutions range from various types of contractual arrangements (hybrids) to quasi or full vertical integration (hierarchy). If the risk of opportunism is perceived to be low, simple spot market exchanges may be the preferred method of exchange. The analysis draws upon case study evidence from three ethanol plants in western Canada: Husky Energy Inc., North West Terminal Ltd., and Pound-Maker Agventures Ltd. Together these three plants represent approximately 30% of the ethanol production capacity in the Canadian prairies. Given their location, all three plants use wheat as a feedstock, and range in size from an annual capacity of 12.5 million litres (Pound-Maker) to 130 million litres (Husky Energy), thereby capturing among the smallest and largest capacity commercial ethanol producers on the prairies (Canadian Renewal Fuels Association, 2010). These firms were chosen for the case study analysis because they are located in the same geographic region within western Canada and because they operate very different business models in terms of size, scope and the core focus of the business activity. As such, the case studies offer insights into how supply chain relationships differ across the sector and are affected by the positioning of ethanol production within the broader business model of the enterprise. As is explained in more detail below, Husky Energy Inc. is primarily an energy producer and fuel refiner, North West Terminal Ltd is a farmer-owned inland grain terminal, while Pound-Maker is an integrated cattle feedlot-ethanol producer. Information for the case studies was gathered through document analysis and interviews with key industry stakeholders. Focusing on governance outcomes, the analysis explores the use of spot markets, contracts and vertical integration by these three western Canadian ethanol producers.

Spot Markets

Spot market transactions usually arise where the threat of opportunistic behavior is low, and involve the simple exchange of a product at current market prices without committing either party to a long-term supply relationship. Given the transaction characteristics that exist in the ethanol supply chain, this type of transaction should be less common. Nevertheless, some interesting examples exist of spot market transactions in the ethanol sector and are worth exploring. One example is the sale of DDGs by North West Terminal Ltd. to livestock farmers across the Canadian Prairies. Located in Saskatchewan, North West Terminal is a producer-owned inland grain terminal which diversified into ethanol production in recent years. With an annual capacity of 25 million litres, the plant lies below the median plant capacity for the region (42 million litres). Having dual roles as a grain marketer and ethanol producer, North West Terminal sells a combination of feed grains (wheat and barley) and DDGs into the regional livestock industry, supplying a range of livestock feed requirements. Offering more feed options than ethanol plants selling only distillers grains gives North West Terminal a potential marketing advantage. It has a sufficiently large and diverse customer base that it can operate primarily as a spot market seller of livestock feed, thus avoiding the necessity of entering into long-term contracts that are sought by other ethanol plants. North West Terminal also has the ability to store 3000 tonnes of DDGs, allowing the company to accommodate changes in demand that occur throughout the year (Holman 2009).

Ethanol plants can make use of spot market transactions to procure grain feedstocks. Although a majority of grain is contracted with grain farmers well in advance (described below), most ethanol plants will accept delivery of grain at spot prices when contracted grain does not satisfy requirements for contracted ethanol production. In these circumstances, the spot market acts as a residual market for the sourcing of grain feedstocks when contracted amounts are not available or are unsuitable. Opportunistically reneging upon previously agreed contracts with grain farmers to take advantage of lower spot prices, however, would lead to a break-down in these supply relationships in the long-run. Thus, the spot market is likely to remain a residual source of supply for most ethanol plants.

Contracting

Contracts are formal agreements between transacting parties, ranging from market specification (marketing) contracts where key elements of the marketing of the product (price, delivery details, etc.) are specified but control over production remains with the seller; to production management contracts where the buyer specifies aspects of the production process such as the use of designated inputs, to resource providing contracts where the buyer provides key inputs as well as providing a market for the output. Contracting seeks to reduce the risk of opportunistic behavior by writing safeguards into the agreement, for example, specifying a fixed price or the basis on which price will be determined, or specifying a quantity and a duration to the contractual relationship that is sufficient to recover sunk investment costs. Similarly, contracts may reduce the transaction costs of sourcing specific quality attributes by requiring the use of certain production processes or inputs. Safeguards often also stipulate compensation in the event that a contract is broken. For this reason, monitoring and enforcement costs can be high in the case of contracting, although this depends on the efficacy of the institutional environment governing the transaction (Hobbs 1996).

Given the volatility in the prices of feedstock grains and distillers grains, as well as uncertainty regarding the market for ethanol in the fuel blending market, ethanol plants often attempt to achieve price stability through contracting for both the supply of inputs and the disposal of output. One of the primary goals of contracting is to lock in prices that make ethanol production profitable and to specify recourse in the event that contracts are broken. Since the inputs and outputs being considered here are relatively homogeneous in terms of quality, it is unlikely that complex production management or resource providing contracts are needed. Instead various types of marketing contracts tend to be used, with two parties agreeing to the exchange of feedstock grains (either corn or wheat), distillers grains or ethanol at a specified price in advance of production for a set time period. In each relationship, both parties benefit from reducing price uncertainty.

Numerous examples exist of the use of market-specification contracts by ethanol producers to reduce price and supply uncertainty, especially as it pertains to grain procurement. North West Terminal, for example, offers its producer shareholders the option to sign a contract to deliver grain for five years at a fixed price for the entire time period. Once this initial contract expires, farmers have the option of renewing this contract on an annual basis for up to ten years. Prices for these contracts are determined by North West Terminal’s annual posted bid price, and farmers can lock in the price of wheat at any time up until the specified delivery date of the wheat (Holman 2009). The Pound-Maker ethanol plant in Saskatchewan has a similar contracting system with its shareholders, although the right of shareholders to deliver is on an annual basis rather than over multiple years. Price is established through a similar process to North West Terminal in its “renewed” contracts, with producers able to lock in prices in advance (Reuve 2009). The ethanol plant owned by Husky Energy in Lloydminster, Saskatchewan offers local grain farmers a similar option to enter into market-specification advance contracts. Survey evidence from Schmidgall et al. (2010) confirms similar findings in the U.S. ethanol sector, with (in addition to cash sales) a variety of procurement contracts used to source feedstocks, including forward contracts, basis contracts, delayed price contracts, and minimum price contracts.

Contracting is also a common feature on the output side of ethanol supply chains (T2 and T3 in Figure 1). Both the North West Terminal and Pound-Maker ethanol plants enter into one- to several-year contracts for the sale of ethanol to fuel blenders. In contrast to grain contracts with farmers, these contracts are quite extensive and specify many details including volume and quality attributes, elaborate pricing formulas, transportation obligations and payment schedules, as well as contingency plans that specify what happens in the event of changes in government policy (for example reduced incentives) or factors of production that can affect output levels. Contracts also contain elaborate compensation scenarios, liabilities and warranties in the event that obligations are not fulfilled. Overall, these contracts represent a fairly high degree of coordination. Finally, Husky Energy markets its DDGs through a long-term relationship with a third party firm, Wilbur-Ellis, which specializes in the marketing and distribution agricultural products through its feed and agribusiness divisions.

While contracting can assist in reducing price uncertainty, it does not completely eliminate the threat of opportunism by either the ethanol plant or by others in the supply chain. Suppose, for example, that a grain farmer agrees via a forward contract to sell grain to an ethanol plant at some point in the future at a specified price. If the price of feed grain increases substantially by the time the transaction is due to occur, the grain farmer has an incentive to act opportunistically by breaking the contract and selling grain at the higher spot market price. Similarly, the opposite scenario could occur if the price of feed grain has decreased after an agreement is made but before the crop is delivered. In this case, the ethanol plant has an incentive to break the agreement and purchase the crop at the spot price in the open market. Anecdotal evidence suggests that these problems occur periodically in both Canada and the US, and are likely to be exacerbated by volatility in grain prices.

Quasi or Full Vertical Integration

In cases where contracts are either too costly to enforce or insufficient to prevent opportunistic behavior, quasi or full integration are more efficient governance structures. Quasi-integration, where two or more levels in a supply chain partially integrate through common ownership or other legal partnership, could be a solution for two firms wanting to remain autonomous or not having the expertise required to fully integrate but recognizing the need to align incentives. Both North West Terminal and Pound-Maker are quasi-integrated with grain farmers who are the primary shareholders in each company. While contracting alone, as described earlier, may work in the absence of joint ownership, the fact that the grain producers are shareholders in the ethanol plant decreases (although does not entirely eliminate) the incentive for opportunistic behavior on the part of grain producers.

In addition to aligning incentives, quasi-integration is an effective strategy for minimizing price risk as a form of hedging. By investing up (down) the supply chain, grain farmers (ethanol plants) provide themselves a measure of protection against substantial decreases (increases) in the price of grains. If grain prices are low, ethanol production becomes more profitable, while if grain prices are high, grain production becomes more profitable, *ceteris paribus*. In an examination of the combined insights from transaction cost economics and positive agency theory, Mahoney (1992) identified output/input price advantages and joint profit maximization strategies as incentives for vertical financial ownership among firms.

In contrast to quasi integration, full vertical integration occurs when a single firm has complete control (ownership) over an upstream (input) and/or downstream (output) stage of the supply chain. If the threat of opportunism is so high that hold-up problems are endemic, the perceived transaction costs associated with safeguarding an investment are higher than the perceived benefits and the exchange relationship breaks down. Vertical integration mitigates these hold-ups.

Clearly, there are a number of scenarios under which both forward and backward vertical integration can occur in the ethanol sector. There are several examples of vertical integration in the western Canadian ethanol industry that could be interpreted as an attempt to reduce the threat of hold-up. In addition to being a farmer-owned ethanol business, Pound-Maker Agventures is also fully integrated down the supply chain with a 28,500 head livestock feeding operation located adjacent to its ethanol plant. Pound-Maker is one of the few ethanol plants that produce wet distillers grains as part of the ethanol production process. Given the asset specific attributes of WDGs, the threat of opportunism is sufficiently high that it is less costly to internalize the transaction within a single a firm than to transact with independent livestock operations. In addition to reducing the threat of hold-up, the combined operation is able to avoid the heating costs associated with drying its distillers grains, as well as costs associated with transporting these grains to feedlots located elsewhere.

Husky Energy Inc., an Alberta-based energy company, provides a second example of the use of full vertical integration to reduce the risk of hold-up. As a gasoline producer, Husky Energy is mandated by federal and provincial governments to blend all of its fuel with ethanol at specified percentages. Rather than dealing exclusively with independent ethanol producers and risking being unable to ensure a consistent supply of ethanol, Husky Energy constructed high-output ethanol plants (in Lloydminster, Saskatchewan and Minnedosa, Manitoba—both with 130 million litre capacities) thereby internalizing the exchange of ethanol within the firm.

While these examples of vertical integration in the ethanol supply chain may be the exception rather than the rule, they demonstrate the difficulty in predicting when and why firms will choose to vertically integrate up or down the supply chain. In some cases, an initial assessment may suggest that vertical integration is the simplest solution, yet other forms of governance are chosen. This is often a result of challenges associated with vertical integration, including sourcing the necessary capital to purchase an existing firm or develop a new integrated business venture, as well as acquiring the knowledge and expertise required to operate what may be a completely new and unfamiliar business with different production processes, thereby going well beyond the core competencies of the firm. Mahoney (1992) categorizes the disincentives to vertical integration as bureaucratic (internal organizational) costs, strategic costs (high exit barriers, sunk investment costs), and production costs (capital costs, operating below capacity). All three are relevant to ethanol supply chains. Despite these challenges, examples of vertical integration, particularly among larger firms, continue to emerge in the agriculture and energy sectors, and a transaction cost lens provides insights into the drivers for closer integration.

Conclusions

The purpose of this paper has been to explore the nature of supply chain relationships in the western Canadian ethanol sector within a transaction cost context. By examining three major relationships involving ethanol producers and the actors with which they transact, the paper assesses the extent to which the transaction characteristics of uncertainty, asset specificity and frequency provide incentives for opportunism, leading to increased transaction costs and in extreme cases, hold-up problems. Table 2 compares the theoretical predictions for governance structure outcomes with the results from the case study analysis of the three firms.

Table 2. Theoretical Predictions and Case Study Outcomes

	Governance Prediction	Case Study	Governance Outcomes
Transaction 1 (Feedgrains)	Spot markets & marketing contracts	NWT[a]	Marketing contracts/quasi integration Spot market-residual supply
		Poundmaker	Marketing contracts/quasi integration Spot market- residual supply
		Husky Energy	Marketing contracts Spot market-residual supply
Transaction 2 (DDGs/WDGs)	Long-term contracts and integration	NWT	Spot market
		Poundmaker	Vertical integration
		Husky Energy	Contract/alliance
Transaction 3 (Ethanol)	Long-term contracts and integration	NWT	Contracts
		Poundmaker	Contracts
		Husky Energy	Vertical integration

Notes. [a] NWT = Northwest Terminal, Ltd.

Based on the predictions from TCE we would expect to find closer vertical coordination in relationships between ethanol producers and buyers of distillers grains (T2) and buyers of ethanol (T3) (i.e. on the output side) than between ethanol producers and sellers of feedstock grains (T1) (i.e. on the input side). An examination of the industry in western Canada shows this to indeed be the case in the transaction with ethanol blenders, where either vertical integration or detailed long-term contracts are the norm. This is true to a lesser extent with buyers of distillers grains, where vertical integration occurs (in the case of Pound-Maker) but so too does some fairly basic short-term contracting (North West Terminal and Husky Energy). Perhaps the existence of large storage facilities and the fact that revenue from distillers grains is not the primary source of income in these cases is the reason why closer coordination has not been pursued.

A somewhat unexpected finding involves the relationship between ethanol plants and grain producers (sellers of grain feedstocks) (T1), where the transaction cost analysis predicts a lower degree of vertical coordination but in fact there exist several examples of quasi integration (Pound-Maker and North West Terminal). In both of these cases the impetus for ethanol production came from grain producers seeking additional markets for their grain, rather than ethanol plants integrating up the supply chain to reduce transaction costs and the threat of opportunistic behavior. Indeed, in cases where the ethanol plant is not producer owned and operated, vertical coordination with grain sellers tends to be characterized by looser arrangements including simple market specification contracts and spot market transactions. Therefore, an understanding of the impetus behind forward/backward integration, whether led by the ethanol plant or by an adjacent set of supply chain actors, is an important corollary to any supply chain analysis of this sector.

The three ethanol plants used in this case study analysis were chosen to illustrate different approaches to the management of supply chain relationships within the ethanol sector, therefore, the results of the case study analysis are somewhat determined by the choice of these three firms. While this is a potential limitation of the current analysis, the intent has been to illustrate how TCE can shed light on supply chain governance and to identify the varied means by which firms mitigate potential sources of opportunism and hold-up within the ethanol sector. While detailed information on all of the contracting strategies used by these firms was not available, the framework presented in this paper offers a basis for further in-depth analysis of contracting strategies, analysis of the development of new ethanol supply chains in other regions, or of the development of second generation ethanol plants using cellulosic feedstock technologies.

A final observation to emerge from the analysis is that several factors evidently influence the choice of governance structure, such that reducing transaction costs is perhaps only one of a number of determinants of vertical coordination strategies. Future analysis could draw upon resource dependence theory, positive agency and property rights approaches to provide a comprehensive understanding of the structure of supply chain relationships. The unique position of ethanol plants at the juxtaposition of multiple supply chains creates a competing set of motivations and demands that also drive governance decisions: whether ethanol plants emerge as a stand-alone investment, as a forward integration strategy by grain farmers seeking a secure output for grains, or as a backward integration strategy by fuel blenders seeking a secure supply of ethanol, crucially affects the nature and evolution of their supply chain relationships. This remains a rich area for further research by business management scholars.

Acknowledgements

Research funding from the Feed Opportunities from the Biofuels Industries (FOBI) Research Network, an Agriculture and Agri-Food Canada funded Agriculture and Bioproducts Innovation Program (ABIP) grant, is gratefully acknowledged.

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International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Multi-Criteria Methodology: AHP and Fuzzy Logic in the Selection of Post-Harvest Technology for Smallholder Cocoa Production

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Abstract

Ecuador supplies 70% of the world's fine aroma cocoa (Theobroma cacao). This paper defines a model of post-harvest technology selection, adapted to small producers, using two multi-criteria models that evaluate the quality, processing cost, and technology adoption capability of each technology. To achieve this result, a preliminary assessment of nine post-harvest technologies is performed, considering only the quality criteria. We then apply the analytical hierarchy process and fuzzy logic methodologies considering the other criteria (processing cost and technology adoption capability). The models provide alternative methods to achieve solutions that reflect the reality of small cocoa producers' decision-making processes.

Keywords: cocoa, small-scale agriculture, post-harvest, analytical hierarchy process, fuzzy logic.

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Introduction

Cocoa post-harvest technology is essential for generating value added for small producers. The postharvest is relevant to Ecuador since the country provides 70% of the world's supply of the 'fine and flavour' cocoa products. The Central Bank of Ecuador (2013) reports that the export of cocoa beans and processed cocoa contributes 1.9% of the country's GDP, representing up to 4% of the employment. In 2012 export volume reached 174,560 metric tons (MT). Almost 60% of the production of fine and flavour cocoa comes from small holders, so decisions on post-harvest operations become relevant for a pro-development export strategy.

Post-harvest operations begin with collection, followed by fermentation and finally drying, prior to marketing.Quality has been considered a relevant criterion for selecting post-harvest technology, because its relevance to determine the price of cocoa in the international market (Amores 2009). However, technology selection in agriculture and post-harvest remain a challenge for small farmers when other economic and social objectives must be considered (Giordano and de Fraiture 2014, Namara et al. 2014). In recent years, an increasing need has emerged to study phenomena from a holistic point of view. Thus, it is important to assess the trade-offs that exist between the quality of the production and other criteria (Castro-Tanzi et al. 2012). In cocoa postharvest, selection criteria such as the processing costs or the technology adoption capability are typically overlooked, which justifies the need for widening the scope of technology selection from a single criterion (quality) to multi-criteria decision analysis (MCDA), including other objectives beyond quality. This paper intends to show the use of MCDA in this context by comparing methodologies that orient postharvest operations in rural areas of Ecuador. This evaluation is carried out considering three criteria: quality, cost of postharvest operations (first processing) and capability of technology adoption by small holders. The last two criteria are considered because small scale production differences are significant in postharvest costs and technology adoption.

Development studies underline the need for enhancing human capabilities to adopt technologies (Ooesterlaken and Hoven 2012). Technology adoption must be eased by the implementation of selection methodologies that are understandable by users and adapt to their characteristics. In this paper, the problem of postharvest selection for small cocoa producers is approached through MCDA that may shed new light on the selection of the best post-harvest technology. This study defines a cocoa post-harvest technology selection model that is suitable for small farmers in the province of Manabi (Ecuador), by applying two alternative multi-criteria methodologies; namely, the analytical hierarchy process (AHP) and fuzzy logic. This is carried out through the following steps: 1) analyse post-harvest techniques that combine fermentation and drying of cocoa beans by using the single criterion of quality. 2) evaluate AHP to choose the best cocoa post-harvest technology, drawing on national experts' assessment, and 3) evaluate fuzzy logic in selecting the best post-harvest technology according to the three aforementioned criteria. Therefore, technology selection in cocoa postharvest is considered with one single criterion method (quality optimization) and two multi-criteria methods (AHP and fuzzy). Though MCDA has been widely used in the environmental management and agriculture (Sipahi and Timor 2010) there is a lack of contributions of MCDA applied to the selection of postharvest technologies by small producers, in particular in cocoa transformation.

Ecuadorian cocoa producers employ a wide range of post-harvest technologies. Our paper will first confirm what other studies have shown when the single quality criterion is applied. Then MCDA includes, in addition to quality, the other two criteria: post-harvesting costs and technology adoption capability and the paper evaluates how retained solutions are sensitive to the multi-criteria method. Both methods are evaluated considering their adequacy for managers or policy-makers work in a context marked by small-scale production.

The paper has the following structure. Section 2 describes cocoa postharvest main fermentation and drying technologies and justifies the use of multiple selection criteria. Section 3 considers the single quality analysis, followed by Section 4, which describes the methodological basis for the MCDA including AHP and Fuzzy logic models. Section 5 presents the results of the post-harvest technology selection the alternative methods and provides with a comparative assessment of solutions and methods. Finally, Section 6 lays out the conclusions of the analysis.

Criteria and Techniques

Papalexandratou et al. (2011b) show that postharvest operations of the cocoa are crucial in developing flavour and colour in the beans. However, Papalexandratou et al. (2013) claim that producers choose postharvest methods depending on the region of origin and practices in the production unit. In other words, besides quality of the output of fermentation and drying operations, other objectives play an important role in the decision of the post-harvest technology by small holders. In this paper, we consider two additional criteria: post-harvesting cost and technology adoption capability. Both criteria are justified as relevant for small holders. We don't neglect the influence of other criteria to approach the selection of post-harvest technologies, such as expected profit, price, and other social, environmental and cultural considerations. Nevertheless, for the purpose of this paper, we aim at showing how MCDA can be applied when data are insufficient and expert assessment is required (Macharis et al. 2004; Scheffler et al. 2014). Expected profit and price are both criteria that can be related to quality and to costs, so we chose to work with orthogonal criteria, with low correlation among them (Savoska and Loshkovska 2014).

Cocoa post-harvesting implies technology, capital, and labour costs that sometimes exceed those of the agricultural phase. This process involves an increase in the value of goods as a result of processing and other services. The specific case of cocoa (from extracting the pod from the tree to trading dry cocoa beans) involves a process of transformation and therefore involves costs, which justifies the inclusion of this criterion in the MCDA.

Technology adoption is the result of a sequence of decisions (Gatignon and Robertson 1991), with the ease of adoption informing the selection of a technology, based on prior knowledge. Sidibé (2004) defines technology adoption as a balance between new technologies and traditional activities. Agricultural research has underlined the relevance of technology adoption capability, in particular in rural areas with significant presence of small holders (Lee 2005; Abdulai et al. 2011; Mariano et al. 2012). In all cases, the subjects of technology adoption are producers, who have their own economic and socio-cultural traits. In this study, as the producer must adopt and implement a post-harvest technology, the technology adoption capability becomes a relevant criterion, which is expressed in this investigation through experts' assessment.

Cocoa post-harvest techniques by small holders in Ecuador consist of a combination of fermentation and drying methods, as the result of a sequential processing process. The fermentation stage is relevant to generate the antecedents of chocolate's aroma and flavour. The type of fermentation affects the quality of the fermented bean (Braudeau 1991, Puziah et al. 1998). The fermentation process may take place in numerous ways, but the traditional methods used by small producers are heap, bags, and boxes (Braudeau 1991).

Later, the drying stage reduces moisture, and the subsequent oxidation phase, which begins during fermentation, completes the maturing process of the aroma and flavour compounds (Jinap et al. 1994, Cros and Jeanjean 1995). During the drying stage, air enters the testa, oxidising part of the polyphenols that remain. This phase marks the continuation of internal biochemical reactions that stimulate the development of flavour and aroma in well-fermented cocoa beans. Concentrations of volatile fatty acids that affect bean quality (Páramo et al. 2010) are also eliminated in the drying phase. During the drying stage, moisture drops to 6 or 7%, the level necessary for storage (Braudeau 1991, Wood and Lass 2001). As in fermentation, there are three traditional drying methods: solar dryers, concrete floors, and racks.

In summary, small producers usually resort to three possible fermentation methods (boxes, heaps and bags) and three possible drying methods (solar dryers, concrete floors, and racks). The combination of the two steps gives rise to nine post-harvest technologies. In the following pages, alternative methods to evaluate technologies are proposed.

Selection Based on Quality

Technology assessment was first carried out using only the single quality criterion, based on the measurement of relevant indicators. The research took place in the Fortalezas del Valle Association collection centre, located in Calceta, Ecuador. The fieldwork was conducted in the dry season of 2012 and the wet season of 2013. The type of experiment followed a completely randomized design, selecting three replicates for each technology. Physical variables for each of the nine combinations were measured in both the dry and wet seasons. In total, 27 samples for each season were assessed, using 10 kilos of fresh cocoa in each sample. The physical variables considered in the empirical research were: percentage of fermentation (good, medium, total, and percentage of violet beans), seed index, and percentage of testa and cotyledons. All these physical indicators are based on measurements from NORMA INEN 176 and ISO 950 (INEN 2006).

To maintain consistency across all data, factors and post-harvest technologies were separately evaluated to test for statistically significant differences between technologies. In the dry season (Table 1), the results of the Duncan ANOVA at 5% revealed an absence of significant differences in the type of fermentation and type of drying for the following variables: percentage of good fermentation, percentage of medium fermentation, percentage of total fermentation, percentage of violet beans and seed index. However, significant results emerged for percentage of testa and cotyledons. Thus, the type of fermentation factor (heap, bags, boxes) or the type of drying (solar dryer, concrete floors, racks) exerts no marked or significant impact on quality. The analysis also considered differences between technologies based on the mixing of fermentation and drying methods (eg. boxes – racks, bag – solar dryer, etc.) which were not found significant.

In the wet season, the results from the Duncan ANOVA at 5% (Table 1) revealed no significant differences in the type of fermentation and type of drying for the following variables: percentage of fermentation (good, medium, total and violet beans). However, the differences in seed index for distinct types of fermentation and types of drying were highly significant. Note that this variable is not directly dependent on post-harvest techniques, as seed index is also influenced by the study material itself due to the inherent genetic variability of the native *Nacional* cocoa in Ecuador. There are also significant differences between drying types in terms of the percentage of cotyledons and testa. For the type of fermentation, however, no significant differences between these variables emerge. With respect to analysis extended to technologies based on combination of methods (not displayed in Table 1) results implied no significant differences for any variables except for the seed index. As explained above, this variable depends heavily on the genetic variability between seeds.

Table 1. Quality indicators by type of fermentation and type of drying

Dry Season[a]

	Factors	Percentage of Fermentation % Good	% Medium	% Total	% Violet	Seed Index	% Testa	% Cotyledons
Type of fermentation	Boxes	22.67	62.44	85.11	14.89	120.76	15.02a	84.98b
	Heap	22.44	59.11	81.44	18.33	114.9	14.8a	85.20b
	Bags	19.78	57.78	77.56	23.56	122.37	13.63b	86.37a
	Standard error	2.08	3.49	3.63	3.68	3.07	0.38	0.38
	Probability	0.56	0.62	0.35	0.26	0.90	0.03	0.03
Type of drying	Racks	22.78	60.44	83.11	16.78	124.76	14.30	85.7
	Concrete floors	22.78	63.67	86.44	14.56	121.35	14.35	85.65
	Solar dryer	19.33	55.22	74.56	25.44	118.81	14.79	85.21
	Standard error	2.08	3.49	3.63	3.68	3.07	0.38	0.38
	Probability	0.41	0.24	0.07	0.11	0.40	0.61	0.61

Wet season[a]

	Factors	Percentage of Fermentation % Good	% Medium	% Total	% Violet	Seed Index	% Testa	% Cotyledons
Type of fermentation	Boxes	62.22	25.33	87.67	12.00	113.82c	15.24	84.76
	Heap	61.22	22.44	84.00	16.00	118.50b	15.06	84.98
	Bags	58.22	26.33	85.67	14.33	121.67a	14.86	85.14
	Standard error	2.33	2.43	1.73	1.74	0.96	0.45	0.45
	Probability	0.46	0.51	0.34	0.28	<0.0001	0.83	0.83
Type of drying	Racks	57.78	26.11	85.00	14.67	113.61b	14.40b	85.60a
	Concrete floors	59.67	25.44	86.22	13.78	118.86a	14.52b	85.48a
	Solar dryer	64.22	22.56	86.11	13.89	121.52a	16.24a	83.76b
	Standard error	2.33	2.43	1.73	1.74	0.96	0.45	0.45
	Probability	0.15	0.55	0.86	0.90	<0.0001	0.01	0.01

[a] The percentages marked by a letter are significantly different from other values under the Duncan ANOVA (α = 0.05) with a confidence level of 95%.

Source. Authors own elaborations based on experimental data

The results are consistent with Amores (2009), although Papalexandratou et al. (2013) indicate that recent research on cocoa fermentation is inconclusive. These results support the hypothesis that the variability of the final quality of the bean depends less on the technology selected and more on the producer's individual performance and environmental conditions. Even if technologies are not decisive for quality, to reach the minimum standards some technologies are more easily implemented than others.

Papalexandratou et al. (2011a) and Lefeber et al. (2011) assert that variability within the production unit and the low degree of standardisation among producers is a consequence of there being several fermentation methods, depending on the region and local practices. These results confirm that, using only the criterion of quality to determine the optimal post-harvest technology is not a far-reaching guide for managers or policy makers in small-scale contexts. Due to the technological diversity, it is therefore necessary to expand the assessment criteria. In the following sections, two additional criteria (processing cost and technology adoption capability) are evaluated using multi-criteria methodologies.

Methodologies for MCDA

In the previous section, technology assessment was based on a single statistical analysis of quality data from the field. We extended the selection problem to consider MCDA with other two methodologies (AHP and fuzzy logic) that allow to enlarging the criteria to consider post-harvest costs and technology adoption capability. MCDA was based on experts' evaluations. In order to facilitate the interpretation of the MCDA in the technology selection for small producers, we avoid mixing AHP and fuzzy in the same MCDA model, as it is carried out by fuzzy-AHP (FAHP) methods (Anojkumar *et al.* 2014).[1]

AHP Methodology

AHP is a measurement theory (Saaty 1980, 1982, 1986) that attempts to describe a general decision operation by decomposing a complex problem into a hierarchical multi-level structure (objectives, criteria, sub-criteria, and alternatives) for decision-making (Saaty and Sagir 2009). The strength of the AHP is that it brings together a diverse group of people to make complex decisions. This methodology is appropriate for everyday decisions and can provide a guideline for the selecting technologies. The AHP methodology has been used successfully in the field of agriculture for sire selection (Stokes and Tozer 2002), the adoption of irrigation methods (Karami 2006), and in the assessment of farming activities for tobacco diversification (Chavez *et al.* 2012), among others. We didn't find reference to MCDA using AHP applied to cocoa postharvest.

The hierarchy of our decision problem has the following structure (Figure 1): (i) The objective is to select the best technology; (ii) the criteria are: quality, processing cost, and technology adoption capability; and (iii) the alternatives are nine post-harvest technologies. Pairwise

[1] According to Zhü (2014) fuzzy AHP does not give a generally accepted method to rank fuzzy numbers and a way to check the validity of the results.

comparisons were then made between these criteria and alternatives, attributing numerical values (from 1 to 9) to identify preferences (Saaty 1980). This process yielded three clusters, whose central axis consists of each of the three fermentation methods (bags, heaps and boxes), which were matched with the drying alternatives (solar dryer, concrete floors, and racks). A 3x3 matrix shows the best alternatives for each cluster.

To provide data for the AHP process, we consulted eight experts with experience in research and development on cocoa production, postharvest, and quality belonging to well-known national cocoa institutions. To merge individual judgments into one representative judgment for the group, the geometric mean was used as by Saaty (2008). The best result for each cluster passed to a second round of assessment to give a final overall result with the best post-harvest technology. In each pairing, an acceptable range of expert judgments was established to avoid inconsistency. This range is measured by the consistency ratio (CR). In this research we used 0.05 for a 3x3 matrix. If the value of CR is equal to or less than this value, the assessment within the matrix can be acceptable (Cheng and Li 2001).

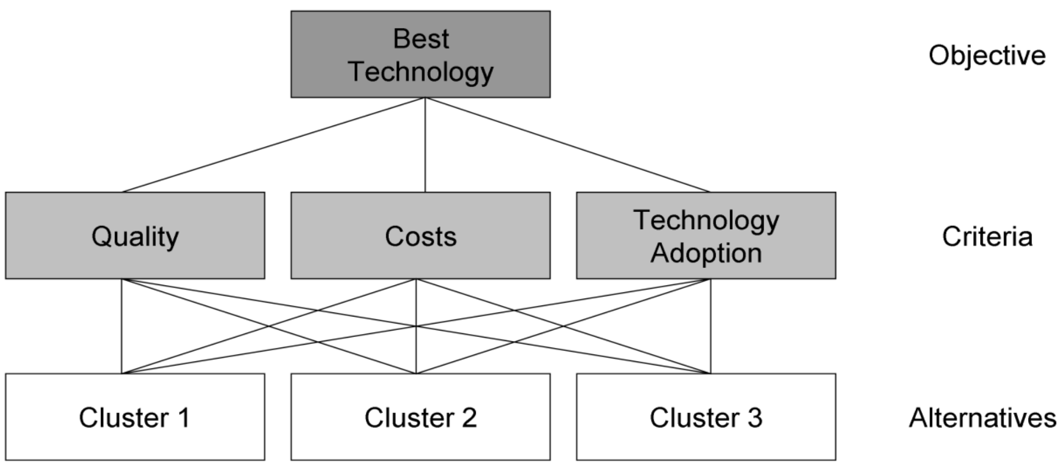

Figure 1. AHP structure for this study

Fuzzy Logic

Fuzzy logic has already been used successfully in the field of agribusiness and agricultural economics (Odetunji and Kehinde 2005, Atthajariyakul and Leephakpreeda 2006). Its methodological basis can be found in Zadeh (1965, 1966) who defines the fuzzy set A in X by a membership function fA (x) that associates each point in X with a real number in the interval [0,1], where fA (x) is the degree of membership of x in A. The closer the value of fA (x) to 1, the greater the degree of membership of x in A.

Fuzzy logic assessment uses a logical sequence of linguistic labels. Labels in our case must adapt to the assessment of post-harvest technologies. For quality the labels used were: ‘very good’,

‘good’, ‘fair’, and ‘bad’, classification that draws on preliminary information from the NORMA INEN 156 (2006) for the classification of cocoa bean quality. For the other two criteria considered (costs and technology adoption), we worked with the same national experts as for the AHP. For processing cost, all experts agreed on three linguistic labels: ‘high’, ‘medium’, ‘low’, taking into account the heterogeneity of the target group (small farmers). Experts described the technology adoption capability as ‘easy’, ‘moderate’, or ‘difficult’ to implement. The output variable consisted of the assessment of the nine post-harvest technologies. The labels were ‘excellent’, ‘very good’, ‘good’, ‘fair’, or ‘poor’.

To allow the evaluation, 36 rules were generated—the result of combining the inputs of all variables with potential outputs (Table 2, see Appendix). The fuzzy rules are those set out by Mamdani (Mamdani and Assilian 1975). Applying fuzzy rules gave rise to fuzzy output sets. The next step was defuzzification, which consisted of transforming these fuzzy outputs into the final set. These values yield the levels of membership of the input values to the different fuzzy sets. The centroid method was used, with three input variables in a 1x3 matrix, a 1x1 output matrix, and 36 rules.

Results and Discussion

We present first the main findings of the cocoa postharvest selection by using first, AHP, and second, fuzzy logic. Then we compare the solutions and evaluate the methodologies having regarded a set of methodological criteria that relate to the adequacy of these methods to the studied problem and other contexts.

Selection of Post-Harvest Technologies using AHP

Experts conducted an individual assessment of each criterion. Quality received the best rating, with a geometric mean of 0.49, followed by processing cost (0.32), and technology adoption capability (0.13) (Table 3). These results are consistent with Amores (2009), who reports that the post-harvest is relevant for marketing a product, taking chemical, physical, and, above all, sensory quality parameters to be the most representative when assessing cocoa. However, the expert assessment confirmed the view that post-harvest costs and technology adoption are not negligible.

Table 3. Preliminary assessment of criteria

Criteria	Minimum	Maximum	Geometric mean
Quality	0.40	0.75	0.49
Costs	0.12	0.46	0.32
Technology adoption	0.07	0.20	0.13

Source. Authors own elaborations based on expert assessment

When boxes are combined with solar dryer, concrete floors, and racks (Table 4), the results reveal that, for the quality criterion, the best technology is boxes-solar dryer with a geometric mean of 0.51. For the cost criterion, the best result is that of the combination boxes-racks, with score of 0.43, which implies that this technology has the lowest cost. The easiest technology to adopt is boxes-concrete floors (0.56). In the overall assessment, the best technology combination is boxes-concrete floors (0.34). This technology attains its highest ratings for the criteria of costs and technology adoption.

The peer review was extended to technologies for the cluster of fermentation in heaps and bags (Table 4). When heaps are combined with solar dryers, concrete floors, and racks, we find that the best technology combination is heap-concrete floors, with a geometric mean of 0.40. It also achieves the best average in the assessment of quality criteria and processing costs in the heaps cluster. Finally, when fermentation in bags is combined with solar dryers, concrete floors, and racks, the best score belongs to bags-concrete floors, whose geometric mean is 0.34 in the overall assessment. In the bags cluster, this technology attains its highest ratings in the assessment of costs and technology adoption criteria, prevailing over the technology considered the best in terms of quality (bags-solar dryer).

Table 4. Assessment of the fermentation clusters

Technologies by Fermentation Cluster	Criteria											
	Quality			Costs			Technology Adoption			Global		
	Min	Max	Geom. M.	Min	Max	Geom. M.	Min	Max	Geom. M.	Min	Max	Geom. M.
Boxes-Racks	0.18	0.38	0.25	0.31	0.53	0.43	0.20	0.32	0.25	0.23	0.36	0.31
Boxes-Solar dryer	0.32	0.71	0.51	0.11	0.15	0.12	0.14	0.24	0.16	0.20	0.56	0.33
Boxes-Concrete floors	0.10	0.32	0.21	0.30	0.56	0.41	0.50	0.62	0.56	0.21	0.46	0.34
Heap-Racks	0.23	0.48	0.34	0.24	0.53	0.36	0.32	0.65	0.43	0.26	0.48	0.37
Heap-Solar dryer	0.20	0.54	0.24	0.08	0.20	0.12	0.10	0.14	0.12	0.12	0.31	0.17
Heap-Concrete floors	0.20	0.54	0.34	0.32	0.62	0.46	0.24	0.55	0.42	0.25	0.54	0.40
Bags-Racks	0.16	0.53	0.28	0.31	0.53	0.40	0.26	0.46	0.32	0.20	0.39	0.33
Bags-Solar dryer	0.32	0.60	0.46	0.10	0.15	0.13	0.10	0.13	0.12	0.21	0.46	0.29
Bags-Concrete floors	0.13	0.32	0.20	0.30	0.56	0.45	0.42	0.64	0.52	0.26	0.41	0.34

Source. Authors own elaborations based on expert assessment

Taking the best result of each cluster, we constructed a further matrix (3x3), which we used to repeat the assessment process and derive the best overall technology. The three technologies chosen from their clusters were: boxes-concrete floors, bags-concrete floors, and heap-concrete floors (see Table 5). For all three clusters, the type of drying is the same because it is relatively cheap and easy to adopt. For the quality criteria, boxes-concrete floors was the highest-scoring technology (0.45). For the cost criterion, the best technology is heap-concrete floors with an average of 0.43. For the criterion of technology adoption, the highest geometric mean is that of heap-concrete floors with 0.42. Finally, the overall evaluation assigns the highest value to heap-concrete floors (0.34), followed by boxes-concrete floors (0.32), and finally bags-concrete floors (0.31).

Table 5. Assessment of the best technologies by cluster

Technologies	Criteria											
	Quality			Costs			Technology Adoption			Global		
	Min	Max	Geom. M.	Min	Max	Geom. M.	Min	Max	Geom. M.	Min	Max	Geom. M.
Boxes-Concrete floors	0.20	0.55	0.45	0.17	0.40	0.20	0.17	0.20	0.20	0.25	0.46	0.32
Heap-Concrete floors	0.19	0.30	0.24	0.40	0.50	0.43	0.40	0.60	0.42	0.25	0.39	0.34
Bags-Concrete floors	0.20	0.50	0.25	0.10	0.40	0.33	0.20	0.40	0.35	0.28	0.40	0.31

Source. Authors own elaborations based on expert assessment

The overall technology scores are very close to each other, although for different reasons, which justifies MCDA in cocoa postharvest. The best technology (heap-concrete floors) has the highest score because of high scores in the cost and technology adoption criteria. In contrast, for the quality criterion, there is a considerable difference in relation to the highest score (boxes-concrete floors). Therefore, quality matters but it is not enough to indicate the best technology, when other relevant criteria are considered in the analysis.

Selection of Post-Harvest Technologies using Fuzzy Logic

Consulting the same group of experts, the degree of membership of the variables and their ranges was classified (Table 6). Fuzzy sets, as well as degrees of membership for each set, were formed for each of the four input and output variables.

Table 6. Ranges of the input and output variables

	Variables	Label	Range
INPUTS	Quality	Bad	0-30
		Fair	20-60
		Good	50-80
		Very Good	70-100
	Cost	Low	0-30
		Medium	20-70
		High	60-100
	Technology Adoption	Easy	0-30
		Moderate	20-70
		Difficult	60-100
OUTPUT	Technology Assessment	Poor	0-30
		Fair	25-50
		Good	45-70
		Very good	65-90
		Excellent	85-100

Source. Ranges established by experts

The experts assessed each technology according to the three criteria (quality, cost, and adoption), leading to the indicated linguistic classification (the first three columns of Table 7).The results of the technology assessment were obtained following fuzzy rules and processing the expert data (the last column of Table 7). The technologies that experts deem ‘excellent’, taking into account all the criteria, were: (i) fermentation in bags and drying with concrete floors; and (ii) heap fermentation and drying with concrete floors. Both combinations employ the same type of drying. Heap fermentation and drying with racks receives the next highest rating (‘very good’).

For the quality criteria, fuzzy results are consistent with the results when only the quality criteria is considered, as only one technology is classified as fair (bags-racks). Therefore, for the quality criterion, all technologies offer the same output quality if they are properly implemented. Differences emerge when the other criteria are also considered. The technologies that have a good rating for processing cost and technology adoption capability are the same as above (heap-concrete floors and bags-concrete floors).

Table 7. Technology assessment using fuzzy logic

Technologies		**Quality**	**Cost**	**Technology Adoption**	**Technology Assessment**	
Fermentation	*Drying*				*Numeric*	*Linguistic*
Heap	Solar dryer	Good	Medium	Moderate	57.5	Good
	Concrete floors	Good	Low	Easy	94.9	Excellent
	Racks	Good	Low	Moderate	77.5	Very Good
Bags	Solar dryer	Good	Medium	Moderate	57.5	Good
	Concrete floors	Good	Low	Easy	94.9	Excellent
	Racks	Fair	Medium	Easy	37.5	Fair
Boxes	Solar dryer	Good	High	Moderate	57.5	Good
	Concrete floors	Good	Medium	Moderate	57.5	Good
	Racks	Good	Medium	Moderate	57.5	Good

Source. Authors own elaborations based on expert assessment

Comparative Evaluation

This paper follows the interest of others (Anojkumar et al. 2014) to compare Multi Criteria Decision Making in order to choose best alternatives. Comparing the three methods (Table 8) reveals a key difference. The single analysis of quality indicators is quite demanding in data but it does not provide with an unambiguous solution to the selection of post-harvest technology. When small holders are at stake, policy makers would need better guidelines for orienting one type of technology or another. AHP and Fuzzy Logic provide a more accurate assessment of technologies using management goals that fit better to the challenges faced by small producers, who in reality make *ad hoc* decisions according to more than one criterion. The three methods use a variety of data sources. The quality assessment used in this paper was quite demanding in statistical data, whereas the multi-criteria methods are based on experts’ evaluations. It is clear, on the other side, that the quality criterion is less subjective than the MCDA applied to this case.

Table 8. Comparison of methodologies

	Single Criterion Statistical Method	**AHP**	**Fuzzy Logic**
Criteria	*Quality*	*Quality, cost, adoption*	*Quality, cost, adoption*
Approach to the reality of small farmers	Low	High	High
Input data	High demanding (field work)	Low demanding (experts' evaluations)	Low demanding (experts' evaluations)
Subjectivity	Low	High (can be reduced in the expert selection)	High (can be reduced in the expert selection)
Methodological basis	Statistical analysis of field data	Formation of hierarchies and the use of peer assessment	Formation of fuzzy sets and rules
Results	No significant differences	Heap-concrete floors	Heap-concrete floors Bags-concrete floors
Possibility for ranking and prioritising	Low	High	High
Level of detail	Low	Medium	High
Extrapolation to new situations	Low	Low	High
Transference to policy makers	Current situation	Potential situation	Potential situation

Source. Authors own elaborations

The MCDA performed in this paper used two alternative selection methods. The methodological basis of AHP is the formation of hierarchies and the use of peer assessment to make decisions (selection of the best technology). In contrast, fuzzy logic focuses on the formation of fuzzy sets and rules, using criteria to determine an output result. In this case, the output variable is the classification of technology assessment into the categories of 'excellent', 'very good', 'good', 'fair,' or 'poor'. Despite their differing methodologies, the results of the two techniques arrive at the same conclusion; namely, that the best post-harvest technology is heap-concrete floors. Both methodologies also give the researcher the possibility for ranking and prioritising the different technologies (Mikhailov 2004). An advantage of the fuzzy method is that it uses linguistic evaluations, which means greater detail during analysis. Furthermore, fuzzy controllers are created during the process. Input data of these controllers could be modified and obtain new results without asking experts again (Odetunji and Kehinde 2005).

The information provided by comparative MCDA allows policy makers to ensure that technology promotion is oriented to improve access for small farmers. Applying a multi-criteria approach to examining the cocoa smallholder sector highlights the reality faced by producers as well as its potential growth (Giordano and de Fraiture 2014).

Conclusions

Producers make decisions based on multiple criteria, an inherent part of human judgment when making choices. Assessing criteria (in this case quality, processing costs, and technology adoption capability) for the choice of cocoa post-harvest technology with multi-criteria methodologies like AHP and fuzzy logic is therefore closer to the reality of the actual choices made by producers. Hence, any technological improvement plan must take into account all of the above criteria on account.

The first specific objective of this study was to assess alternative post-harvest technologies, combining fermentation and drying techniques of cocoa beans under a single quality criterion. This analysis revealed no significant differences, in terms of physical metrics of cocoa quality, between the two factors (i.e., type of fermentation and type of drying) and technologies. In other words, statistically speaking, under the criteria of quality, claims to have a better post-harvest technology are ambiguous. Differences between the quality of different producers' cocoa are not dependant on the technology selected.

The research considered MCDA to take into account the criteria of quality, post-harvesting costs, and technology adoption capability. AHP attached the quality criterion the greatest weight, but quality was not always decisive when selecting the best technology because some technologies receive high scores for the other two criteria, thereby offsetting the quality criterion score. Fuzzy logic yielded results that are similar to those of the AHP methodology, indicating that the experts' judgments are coherent. Moreover, fuzzy logic results were also consistent with the statistical results of the first analysis (in terms of quality), as the results of the fuzzy logic analysis were similar to the ratings of the quality criterion for eight of the nine technologies.

Other socio-economic and environmental benefits, such as, environmental impacts, private earnings or prices, are not considered (quality is closely related to its market value). However, the way has been paved for new criteria in next steps. Finally, our findings lead to an important research question: what is the optimal multi-criteria methodology? The answer lies in the quality of the data provided by experts and the scope of the research aims. As a closing remark, policymakers can apply MCDA to develop cocoa policies taking into account the relevance of these multiple criteria, and having discriminatory elements beyond the single criterion of quality. In the same way, managers can also benefit from MCDA when cooperative forms of production are carried out.

Acknowledgements

The authors wish to thank the Ministry of Economy and Competitiveness (MINECO, Spain) and the European Regional Development Fund in the framework of the Agriinnova project 'Organizational forms of innovation in agri-food sector and its effects on economic outcomes and innovation performance' (AGL2012-39793-C03-02) for their financial support. The authors also express their gratitude to the Escuela Superior Politécnica Agropecuaria de Manabí 'Manuel Félix López' for their support in the preparation of the experimental fieldwork.

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Appendix

Table 2. Fuzzy rules

Rules No.	If QUALITY is	and COST is	and TECHNOLOGY ADOPTION is	Then TECHNOLOGY ASSESSMENT is
1	Very Good	High	Easy	Good
2	Very Good	High	Moderate	Good
3	Very Good	High	Difficult	Fair
4	Very Good	Medium	Easy	Very Good
5	Very Good	Medium	Moderate	Very Good
6	Very Good	Medium	Difficult	Good
7	Very Good	Low	Easy	Excellent
8	Very Good	Low	Moderate	Excellent
9	Very Good	Low	Difficult	Very Good
10	Good	High	Easy	Good
11	Good	High	Moderate	Good
12	Good	High	Difficult	Fair
13	Good	Medium	Easy	Very Good
14	Good	Medium	Moderate	Good
15	Good	Medium	Difficult	Fair
16	Good	Low	Easy	Excellent
17	Good	Low	Moderate	Very Good
18	Good	Low	Difficult	Good
19	Fair	High	Easy	Fair
20	Fair	High	Moderate	Fair
21	Fair	High	Difficult	Poor
22	Fair	Medium	Easy	Fair
23	Fair	Medium	Moderate	Fair
24	Fair	Medium	Difficult	Fair
25	Fair	Low	Easy	Good
26	Fair	Low	Moderate	Fair
27	Fair	Low	Difficult	Fair
28	Bad	High	Easy	Poor
29	Bad	High	Moderate	Poor
30	Bad	High	Difficult	Poor
31	Bad	Medium	Easy	Poor
32	Bad	Medium	Moderate	Poor
33	Bad	Medium	Difficult	Poor
34	Bad	Low	Easy	Fair
35	Bad	Low	Moderate	Poor
36	Bad	Low	Difficult	Poor

Source. Authors own elaborations

International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Mapping and Quantification of the Beef Chain in Brazil

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Abstract

GESis (Neves 2008) is a practical process for developing strategic plans for production chains and was applied in several projects in Brazil. One of the initial steps is mapping and quantification of production chains. This step provides knowledge of the size of the chain analyzed, in terms of social and economic magnitude. Using the method GESis, the main objective of this article was to estimate the financial transactions for one of the most important production chains to Brazil, the beef chain. In this research, the gross value of the beef sector in Brazil was estimated at $167.5 billion in 2010. This material can serve as a stimulus to public and private decision-making and it shows the intimate interconnection between the links in the chain and its ability to generate revenues, taxes and jobs.

Keywords: beef, mapping, quantification, production chain, Brazil.

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Introduction

The mapping and quantification of agribusiness chains in Brazil has been the subject of several studies. The first focused on the wheat chain by Rossi and Neves (2004), followed by the orange juice sector (Neves and Lopes 2005), the milk chain (Consoli and Neves 2006), the sugarcane chain (Neves et al. 2010), the citrus chain (Neves and Trombin 2011), the cotton chain (Neves and Pinto 2012), and the beef production chain—the findings of which are presented in this paper.

These studies aim to generate detailed information concerning the magnitude of economic and social development of the production chains in the country. The analyses range from orchard inputs to the products offered to consumers.

This study answers the following questions:

- how significant is the sum of sales of the various links in the supply chain?
- how much tax revenue is generated by the production chain?
- how many direct and indirect jobs are generated in Brazil?
- how significant is the sum of wages paid to workers during a season?

A complete overview of a production chain is essential to providing greater transparency to the sector, clarifying and questioning fallacies, as well as adding value to the image of the chain. The information collected contributes to the market intelligence that can support structuring a strategic plan in order to identify innovations in business and explore new opportunities that can raise the competitiveness of the sector. This information may also be used to support decision-making in both the public sector and with companies operating individually or collectively. The objective of this study is to estimate the financial transactions of the beef chain in Brazil, thereby providing further insight into this sector.

Theoretical Framework

Two traditional approaches to studying chains can be found in the literature. The commodity system approach (CSA) which was developed by Goldberg (1968) studying citrus, wheat, and soybean production systems. The CSA methodology emphasizes the sequence of product transformations in the system. The merit of Goldberg's method is that it changed the focus of analysis so it was applicable to the entire system, thereby allowing researchers to consider the agricultural sector without isolation from the overall economy.

The second approach, proposed by Morvan (1985), considers a chain ("filière") linked through operations in the transformation of goods. The chains are influenced by technology and have complementary interdependences, according to Batalha (2001). According to Morvan (1985), the filière analysis is an important tool for describing systems, defining the role of technology in the framing of production systems, organizing integration studies, and in analyzing industrial policies, firms, and collective strategies.

The supply chain is viewed as a system that integrates raw material suppliers, factories, distribution services, and consumers (Stevens apud Omta et al. 2001). Because efficient management is critical to the survival of productive chains, Folkerts and Koehorst (1997) proposed a model for managing supply chains that specifically focused on the linkages between the actors in the chain. The model highlighted to two key aspects: system performance and factors critical to success. Furthermore, there is a network concept in which organizations are involved in different stages of the processes and add value from the development phase of goods and services until they reach the consumer (Christopher apud Omta et al. 2001). Lazzarini et al. (2001) integrate chain and network concepts in a study on net chains. According to these authors, integrating these approaches enable existing organizational interdependences in a network to incorporate different mechanisms of coordination: managerial plans, process standardization, and adjustments, and sources of value into production through operation optimization, transaction cost reduction, diversity, and "co-specialization" of knowledge.

To Fearn, Martinez, and Dent (2012), the value chain analysis (VCA) should be used to identify the current state of a value chain and possible improvements for the future. The authors propose three facets essential to creating a sustainable value: limits of analysis (intra-firm, inter-firm and external stakeholders), values considered (cost reduction, consumer value and shared value) and type of governance.

Gereffi, Humphrey and Sturgeon (2005) proposed a model containing five different forms of governance and ascertain that those closest to the reality faced by specific sectors are important not only for the development of policies, but also to anticipating possible changes in the chains. Their model does not quantify financially productive chains, but can complement other models which are more quantitative and the combination of the two can be a more powerful tool. Korzeniewicz and Gereffi (1994) also consider governance and the study of the relationships between actors to be fundamental in the analysis of value chains.

The competitiveness of an agribusiness system can be analyzed from three different fronts: private strategies, collective strategies and public policies that contribute either collectively or separately to create value in the system (Zylbersztajn and Neves 2000). An important focus in creating value chains is the attempt to transfer value to products economically treated as commodities. Kaplinsky (1998) identifies nine critical areas in value chain assessment: basic resources, policies, technology, human resources, organizational, relational, and product marketing, infrastructure and financial.

Kaplinsky and Fitter (2001) sought to identify how value is generated along the production chain. They analyze the global coffee chain, employing a method for mapping and quantification of this sector. Their subscribed method is interesting as it incorporates the variable geographic location, showing clearly which steps are essentially developed countries producers and which are made in consumer countries. According to the authors, to achieve a more equal global distribution of income in the coffee chain, consumers should be educated to recognize that better coffees are directly linked to their place of origin rather than to their brand names.

A study by Hardman et al. (2002) provides an example demonstrating the possibility of increasing the competitiveness of South African apple chain exportations through cooperation among producers, packers, and exporters. From the ideas of CSA and the filière, it is possible to develop tools and managerial activities to improve the chains' efficiency. Thus, the concepts of Supply Chain Management (SCM) and the set of networks and net chain ideas are important theoretical concepts and empirical notions for the development of food and bioenergy chains (Batalha and Silva 2001). Gripsrud, Jahre and Persson (2006) state that SCM can be considered as an attempt toward joining two current studies known as "business logistics" and "marketing channels."

Kaplinsky and Morris (2000) point out that the methods of quantification on supply chains tend to result in a tree of input-output flows, which carry all the information gathered. The data can be found in different primary and secondary sources, such as annual reports, balance sheets, and interviews with key respondents in each link of the chain involved in research and other areas.

In this work, the GESis method of quantification was chosen. The steps of the GESis quantification method are presented in detail in the methodology section. From the bibliography and thorough analyzing the method, some advantages and disadvantages concerning use are highlighted. In terms of the operating method, the phases of GESis is clearer and better defined.

The initial in-depth interviews that are used seek to validate the design of the agribusiness system in question, give more credibility and veracity to the final outcome. Also, the experts can see the schematic view of the whole process and can discuss it. The result of the interviews with experts to estimate the total amount sold by companies is compared with the data declared by the following link, giving greater accuracy to the estimates. So, the amount declared by the vendors is compared with the amount declared by the buyers. For example, the amount declared by the Packing Industry about the sales of packing to the meat sector was compared with the amount declared by the slaughterhouses with this item.

Another advantage in using the GESis method occurs in the steps following the interviews with experts. In these steps there are two validations of the estimated values. The data is first sent to the companies involved to obtain their approval. Then, a workshop is organized where the values are presented to experts for discussion until a consensus is reached.

Thus, to avoid any direct influence on data that a researcher could have, the method adds steps to validate the data with experts, giving greater credibility to the study.

A disadvantage of the GESis method compared to the method proposed by Kaplinsky and Fitter, (2001) or the method proposed by Fitter, Robert and Kaplinsky (2001), is that GESis does not make the drivers of values to the productive chain explicit and does not show which link in the production chain benefits the most from the added value.

Moreover, some authors (Fearn, Martinez and Dent 2012; Gereffi, Humphrey and Sturgeon 2005; Gereffi and Korzeniewicz 1994) consider the analysis of governance essential to the completing the understanding of the value chain. The GESis method does not include this type of analysis, but for the purpose of this manuscript the method is sufficient.

Methodology

According to Malhotra (2006), in order to characterize and analyze a production chain, it is necessary to define its objectives, boundaries and scope, participant subsystems of the production chain, and its environment. Batalha (2001) reports that in order to analyze a chain, the researcher must define certain conditions that are consequences of the objectives to be reached. The most important and difficult definitions are related to the scope of the analysis and levels that should be detailed. Zylbersztajn and Neves (2000) comment that the definition of the agro-industrial systems boundaries shall be dependent on the research purposes, which are generally focused on a product.

The present work was conducted through exploratory research based on secondary data and in-depth interviews using GESis, the method proposed by Neves (2008). According to Malhotra (2006), exploratory research is used when your main goal is to better understand a situation by bringing more information forward about the studied subject. There is no pretension to test specific hypotheses (Hair, Money and Samouel 2005).

The method used below outlines every action performed at each stage of the method. As summarized in Figure 1, the method consists of a five-step process towards implementing strategic management within a production chain.

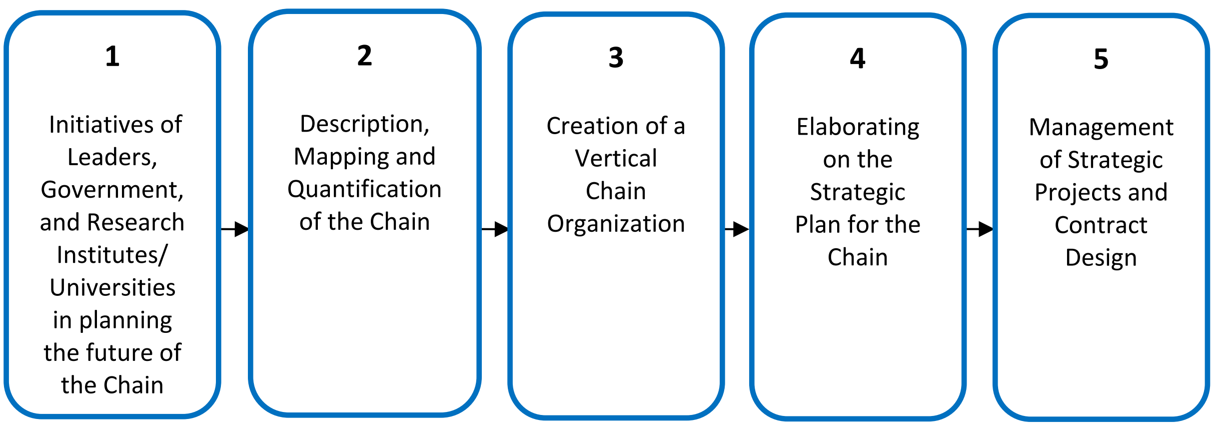


Figure 1.The GESis method for strategic planning and management of food and bioenergy chains.
Source. Neves (2008).

The second step of the method consists of mapping and quantification of chains. This step comprises seven stages, as shown in Figure 2. Its application is relatively straightforward and the collection of information does not depend on public sources of data, which is another advantage of this method. In addition, the figure obtained allows easy visualization of the positioning and relevance of different sectors in an existing value chain.

The first of the six steps consists of elaborating a preliminary design of the chain based on theory and the researchers' experience. It is also necessary to define the scope of which segments will be studied, keeping the focus on the central axis of the system, and research objectives. In this paper, following Goldberg's (1968) notion of commodity system approach (CSA) the focus of this value chain analysis is beef as the raw material, the central object of the system, and the starting point for the system analysis.

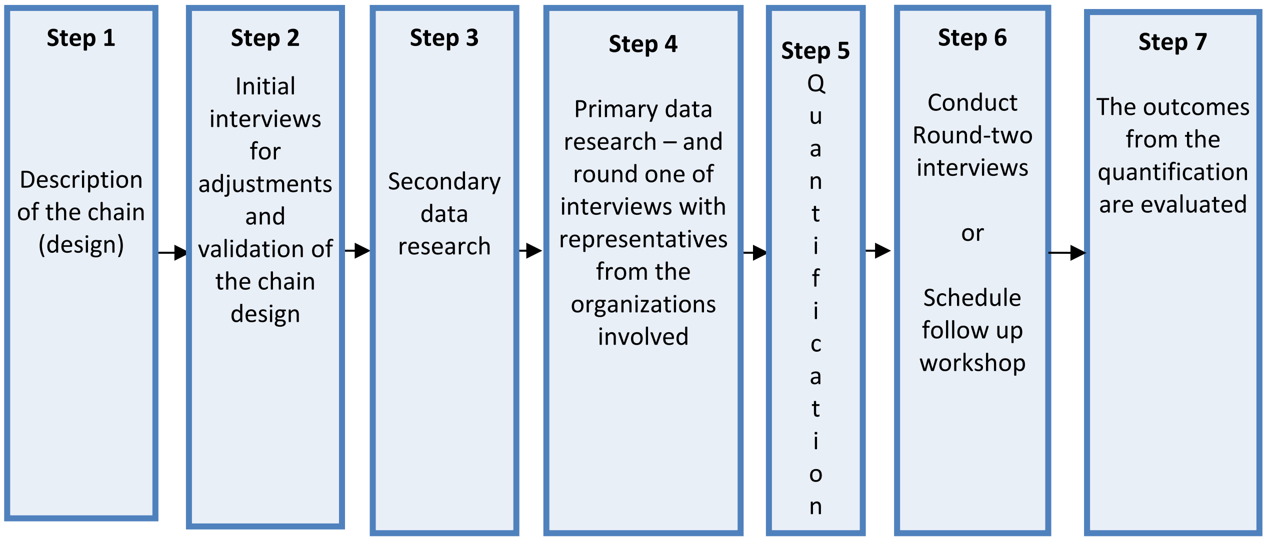


Figure 2. Method for mapping and quantification of the chain adapted.
Source. Neves (2008).

After the production chain is designed, the second step is to submit it to the sector specialists and interview them, as they will have to propose possible adjustments, in order to obtain the current condition of the system.

The third step consists of secondary data research, which according to Malhotra (2006) is collected for outcomes that differ from the research problem. For this step, data was gathered from sources that have academic and statistical credibility, reputation, and integrity.

After gathering the available secondary data, we started collecting the primary data (Stage 4), the data originating from the researcher for the specific purpose of solving the problem in question (Mattar 1993; Malhotra 2006). This included in-depth interviews conducted with representatives from several organizations in the beef sector.

To select and define the interviews, we first identified which data was not found in the secondary research. From this point, agents in the chain were selected for interviews. To be selected, the agent should have certain characteristics. They must have access to the information and data of the sector under investigation. They must have knowledge and experience about the system and they must be willing to collaborate with the researchers and promote communication for future contacts. Finally, they must be able to identify possible contact agents who will contribute with unavailable data.

The fifth step, quantification, determines the turnover of each sector in the chain through company revenues and estimates of several sub sectors of the beef production chain. Therefore, it is important to delineate the period of the research evaluation. In order to ensure confidence in the data, some secondary and primary data were contrasted, attempting to find incongruous elements. In this process, at least two different data sources were used to check the results and bolster with additional interviews with similar agents as needed.

In the sixth step, a second round of interviews were performed, rather than following with a workshop as recommended in the GESis method. There was great concern about whether interviewing the same agents again in all the links of the chain would generate a good discussion and data validation. In this second round of interviews, the results from the first round were presented, providing the respondents an opportunity to change their answers and to comment on the emerging and collective perspective of the research participants.

The seventh step provided a consolidation and revision of the data and the outcomes from the quantification are evaluated.

Results and Discussions

For the purposes of comparison, with a didactic aim, the beef production chain was divided into four segments: (1) before the farm, which comprises the links of agricultural and livestock suppliers; (2) on the farm, which encompasses the production of livestock; (3) after the farm, which is composed of the links of industrial supplies, the processing industry, and distribution; and finally (4) facilitating agents. Figure 3 (See Appendix) shows the design of the beef production chain and the values of each link in the chain indicating overall sales in that link, as a function of products or services sold to this production chain.

Before the Farm

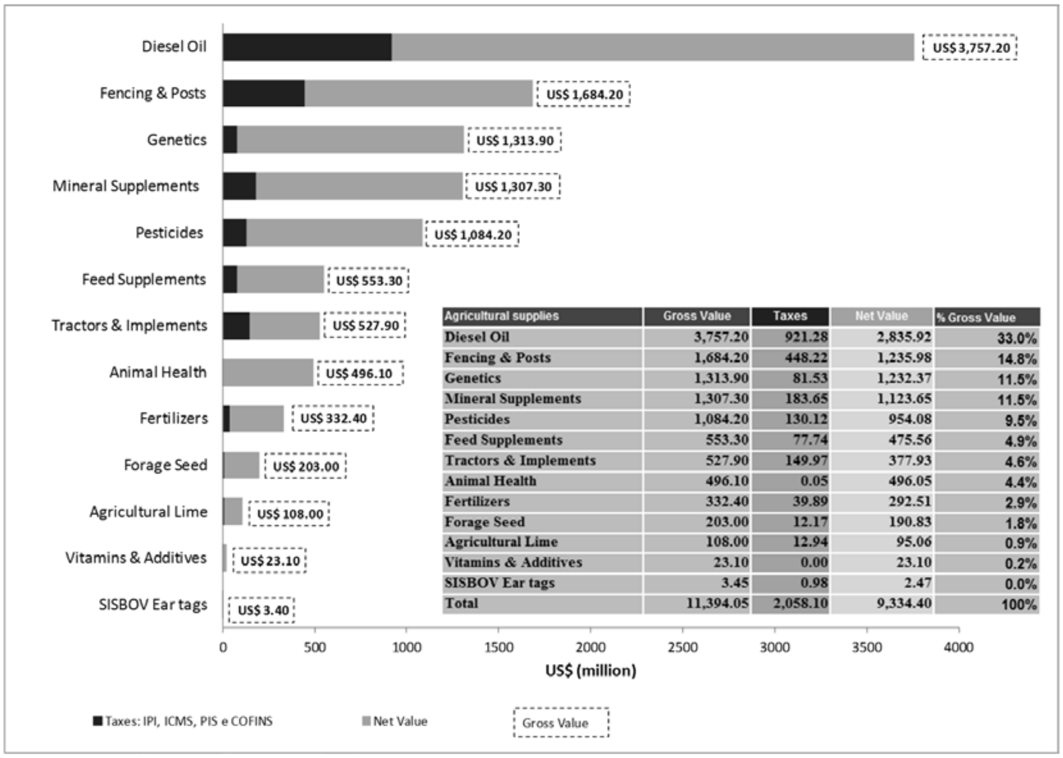
The agricultural and livestock supplies used in the production of beef cattle generated gross revenues of $11.39 billion in 2010 for each link in the production chain as shown in Figure 4.

On the Farm

A total of 655,000 head of live cattle was exported in 2010, generating estimated revenue of $658.7 million. The animals sent to slaughter amounted to 681 million *arrobas* (unit of measure equal to 15 kilos or 33lbs of dressed carcass) generating estimated revenues of $30.8 billion. Of that total, finished steers (over 36 months of age) represented 62% of overall slaughter; cows accounted for 24%; young bulls (24 to 36 months) 13%; and veal (less than 24 months) less than 1%.

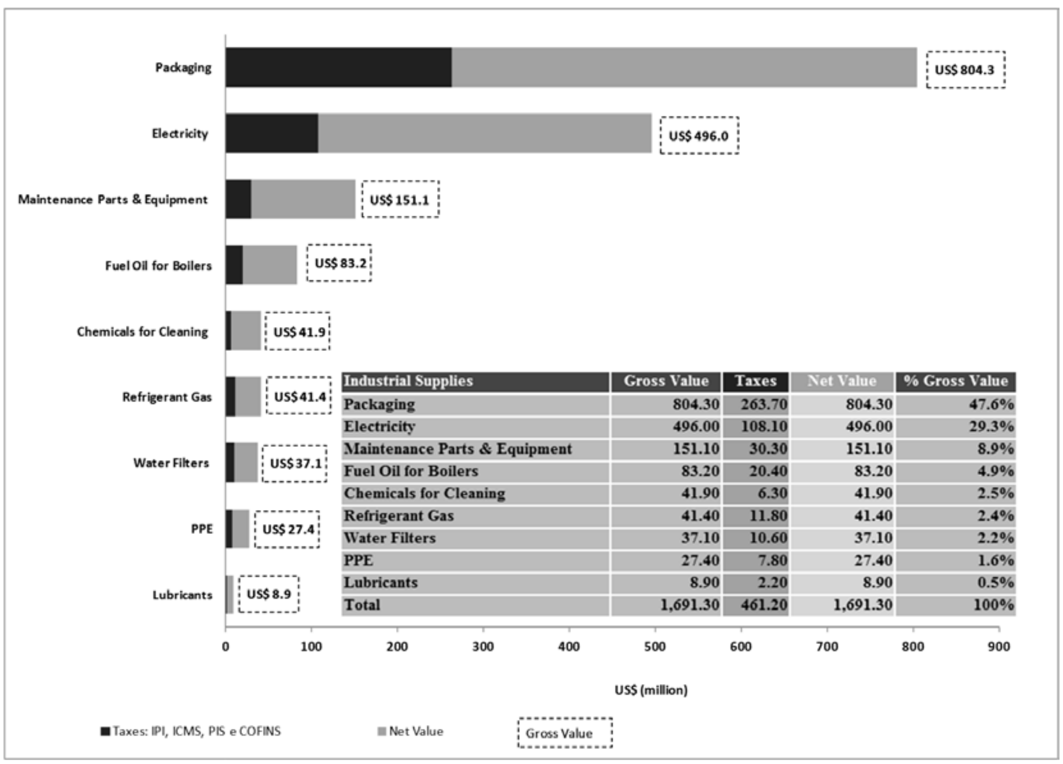
After the Farm

The purchase of industrial supplies used by slaughterhouses in the production of beef and other products accounted for an estimated $1.69 billion, around 1% of the gross value of the beef production chain. Figure 5 shows the share of each of the inputs used by industries in the production process.



Agricultural supplies	Gross Value	Taxes	Net Value	% Gross Value
Diesel Oil	3,757.20	921.28	2,835.92	33.0%
Fencing & Posts	1,684.20	448.22	1,235.98	14.8%
Genetics	1,313.90	81.53	1,232.37	11.5%
Mineral Supplements	1,307.30	183.65	1,123.65	11.5%
Pesticides	1,084.20	130.12	954.08	9.5%
Feed Supplements	553.30	77.74	475.56	4.9%
Tractors & Implements	527.90	149.97	377.93	4.6%
Animal Health	496.10	0.05	496.05	4.4%
Fertilizers	332.40	39.89	292.51	2.9%
Forage Seed	203.00	12.17	190.83	1.8%
Agricultural Lime	108.00	12.94	95.06	0.9%
Vitamins & Additives	23.10	0.00	23.10	0.2%
SISBOV Ear tags	3.45	0.98	2.47	0.0%
Total	11,394.05	2,058.10	9,334.40	100%

Figure 4. Estimated revenue and relative share of the links of agricultural/livestock supplies in the "before-the-farm" segment in 2010.



Industrial Supplies	Gross Value	Taxes	Net Value	% Gross Value
Packaging	804.30	263.70	804.30	47.6%
Electricity	496.00	108.10	496.00	29.3%
Maintenance Parts & Equipment	151.10	30.30	151.10	8.9%
Fuel Oil for Boilers	83.20	20.40	83.20	4.9%
Chemicals for Cleaning	41.90	6.30	41.90	2.5%
Refrigerant Gas	41.40	11.80	41.40	2.4%
Water Filters	37.10	10.60	37.10	2.2%
PPE	27.40	7.80	27.40	1.6%
Lubricants	8.90	2.20	8.90	0.5%
Total	1,691.30	461.20	1,691.30	100%

Figure 5. Estimated revenue and relative share of the links of industrial supplies in the "after the farm" segment in 2010.

Sources. Figures 4& 5. Neves et al. (2012) prepared with data generated by Markestrat and Scot Consulting.

In 2010, the slaughtering capacity at the establishments registered with the Federal Inspection Service (FIS) was roughly 163,000 head per day. The slaughter capacity of establishments registered with the State Inspection Service (SIE) was estimated at approximately 35,000 head per day (of the 21 states that responded to the survey). Therefore, the annual slaughter volume in Brazil has reached 60 million head of cattle. There are also slaughterhouses and meat-packing plants inspected by the Municipal Inspection Service, whose slaughter capacities are not accounted for due to the difficulty of accessing the appropriate secretariats from all the municipalities. With the slaughter of 43 million head in 2010, we conclude that Brazil used 71% of its installed beef slaughter capacity.

Estimated revenues of slaughterhouses in 2010 were US$42 billion[1]. Of this, meat sales totaled $35.8 billion and the sales of other products totaled$6.2 billion. In relation to sales by market, domestic sales accounted for 89%, while exports represented 11%.

Considering only beef, the domestic market absorbed 91% of all volume produced in Brazil, generating $31.9 billion in sales for the slaughterhouses.

The products for industrialization on average are comprised of 59% forequarter cuts and 16% hindquarter cuts, 3% plate, and 22% edible byproducts for industrialization (heart, meat around the point of exsanguination, skin, tendinous meat, tongue, flank, as well as tendon and diaphragm membrane). Sales of meat and edible byproducts represented 6% of the volume of slaughterhouse production destined for the domestic market, with estimated total sales of around $1.9 billion. Of this total, $322.8 million referred only to edible byproducts for industrialization and $1.6 billion to beef cuts.

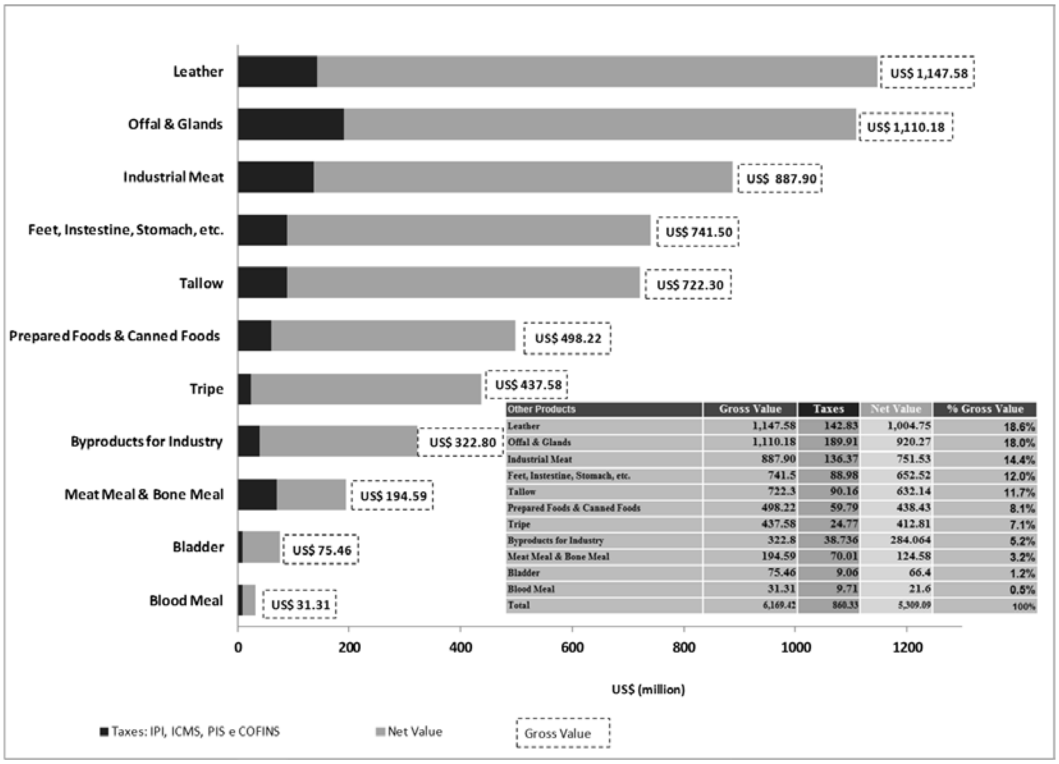
Sales of beef to distributors/wholesalers generated estimated revenue of $10.5 billion for slaughterhouses. The estimated revenue of slaughterhouses from direct sales to retailers was $19.9 billion, representing 60% of the volume of beef sold by slaughterhouses on the domestic market. Beef exports generated revenues of $3.9 billion, resulting from the sale of 953,000 tonnes, establishing Brazil as the world’s largest beef exporter, with 20% of the international trade. Figure 6 shows the values of estimated revenues of slaughterhouses from the sale of other bovine products, the respective sales taxes, and the relative share of each item in the sales revenue from such products.

The primary revenue-generating byproduct for the meatpacking industry is rawhide. The sector’s estimated revenues from sales of rawhide (also called salted leather) were $1.1 billion on the domestic market. In 2010, leather exports generated revenues of $1.7 billion for tanning industry. Brazilian exports of this product represented 6% of worldwide leather exports, ranking Brazil fourth among leather exporting countries.

Estimated revenues of distributors/wholesalers from the sale of meat and edible byproducts were $14.5 billion in 2010, out of which 96% resulted from sales of beef and 4% from sales of byproducts. Approximately 36% of the volume of beef and 41% of beef byproducts sold by

[1] All revenue reported within this research is calculated in US Dollars.

slaughterhouses on the domestic market passed through a distributor/wholesaler before reaching the final consumer.



Other Products	Gross Value	Taxes	Net Value	% Gross Value
Leather	1,147.58	142.83	1,004.75	18.6%
Offal & Glands	1,110.18	189.91	920.27	18.0%
Industrial Meat	887.90	136.37	751.53	14.4%
Feet, Instestine, Stomach, etc.	741.5	88.98	652.52	12.0%
Tallow	722.3	90.16	632.14	11.7%
Prepared Foods & Canned Foods	498.22	59.79	438.43	8.1%
Tripe	437.58	24.77	412.81	7.1%
Byproducts for Industry	322.8	38.736	284.064	5.2%
Meat Meal & Bone Meal	194.59	70.01	124.58	3.2%
Bladder	75.46	9.06	66.4	1.2%
Blood Meal	31.31	9.71	21.6	0.5%
Total	6,169.42	860.33	5,309.09	100%

Figure 6. Estimated revenue of slaughterhouses from sales "Other bovine products."
Source. Neves et al. (2012) prepared with data generated by Markestrat.

Sales of meat and edible byproducts on the retail market accounted for around 53% of the volume sold by slaughterhouses, amounting to estimated revenues of $42.9 billion. Major retail chains accounted for 62.2% of total revenues from sales of beef and beef byproducts, i.e., $26.7 billion, while small and midsize retailers earned $16 billion, equivalent to 37.4%. The remainder (0.4%) was earned by slaughterhouses selling directly to consumers, through their own stores. The estimated revenue from overall sales of beef by the retail market was $40.3 billion.

Imports of products of the beef cattle production chain totaled $246.8 million. The main product imported by Brazil was meat, which represented 66% of the value imported, followed by leather (23%), and other products and byproducts, which accounted for 11%.

Facilitating Agents

By the end of 2010, according to the Annual Social Information Report (RAIS), there were 580,500 people employed in activities directly related to the beef sector. This figure includes jobs in cattle raising (65% of the total number), slaughter (19%), manufacture of meat products (9%), and leather tanning (7%). Indirect employment, which represents the number of jobs created by the production chain of the supplies used in raising cattle, accounted for 2.37 million jobs. Induced employment, which represents the number of jobs generated by the income that the cattle industry provides, accounted for an estimated 3.37 million jobs. In all, the cattle industry was responsible for 6.32 million jobs in 2010. Based on the number of formal employees and average wages, we estimated the sector's payroll at around $3.9 billion in 2010.

Conclusions

This paper aims to map and quantify the productive chain of Brazilian beef by the method GESis proposed by Neves (2008). The goal was achieved as expected, but a small adjustment to the original method was required. The modification of replacing the workshop stage for a second round of interviews in which the first round results are presented gave the opportunity to respondents to change their answers and to comment on the emerging and collective perspective of the research participants. Individual interviews in this stage brought important contributions by making participation more convenient to the respondent and providing greater freedom for the display of data and opinions, without constraining the respondent publicly. The need for this change was observed from the application of the method to quantify the beef sector in Brazil.

Thus, the article has reached its goal by presenting the results obtained from applying the method to the beef production chain and noted that the adaptation to the method introduced by Neves (2008) proved to be a suitable alternative to the research. It can further be understood as a possible approach for convergence of data and opinions. The study is limited by the dependence of the method on subjective opinions. In theory, the method can be used for any sector; however, other adjustments may be necessary, depending on their specificity.

This material serves as a stimulus to decision making in the public and private sectors, and shows the strong connection between the links of the production chain and their amazing ability to generate resources, taxes and jobs. The expectations are that studies such as this one – which depict the reality and importance of the agribusiness production chains – will not stop here, but will be broadened and become part of an information system that more frequently promotes critical data to be able to bring more transparency to the sectors and support for strategic decision making.

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Appendix

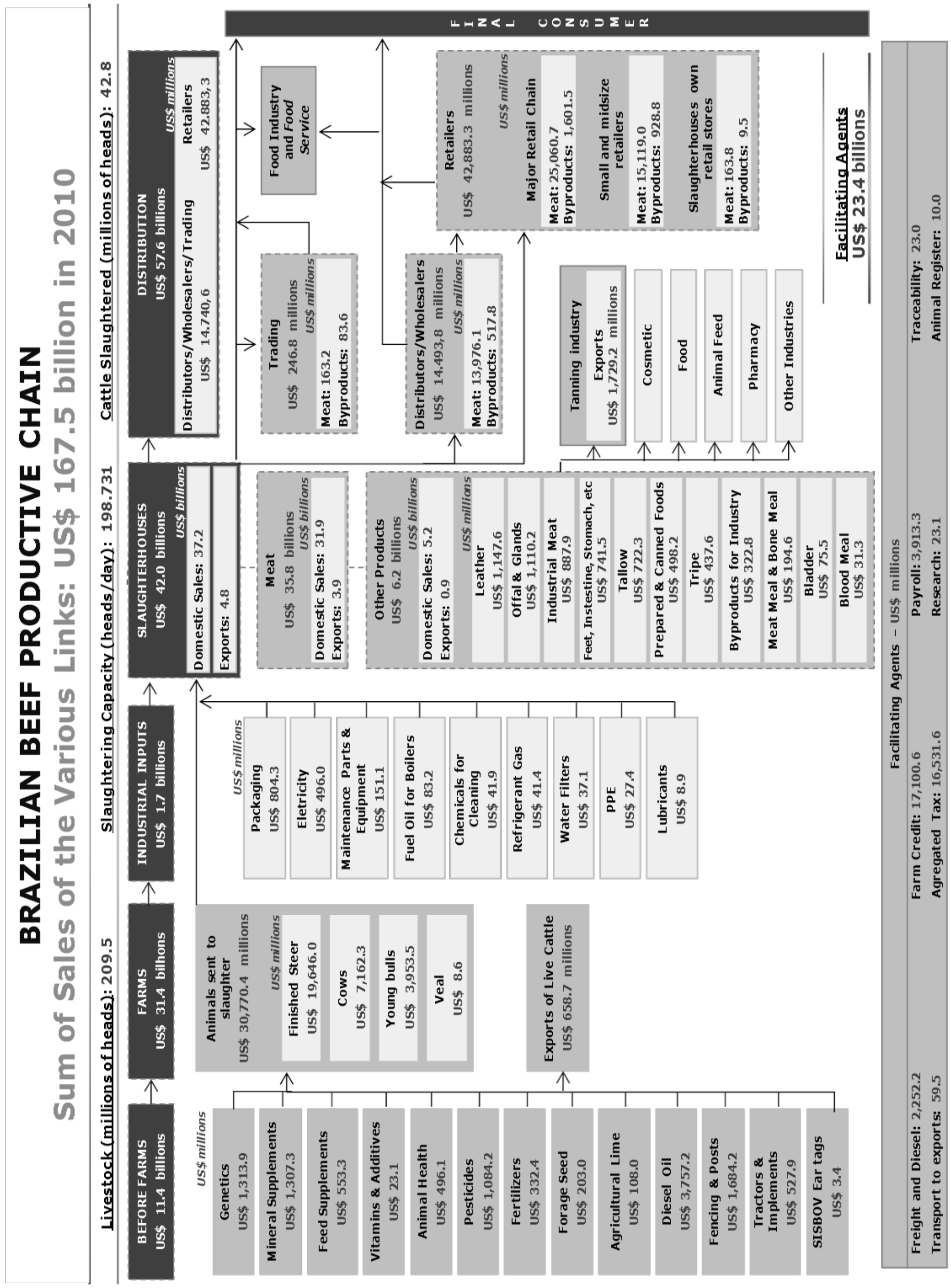

Figure 3. Brazilian beef chain gross revenue from sector products and services.
Source. Neves et al. Prepared from data generated from Markestat and Scot Consulting.

International Food and Agribusiness Management Review
Volume 17 Issue 2, 2014

Advancing Agricultural Productivity in Africa

An Executive Interview with

Eric Raby, Vice President of Global Marketing and Commercial Development, AGCO[1]

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Abstract

AGCO is a leading manufacturer of agricultural equipment founded in the early 1990s. They sell a variety of tractors, forage and tillage equipment, implements and hay tools in more than 140 countries worldwide. In 2012 AGCO's sales reached nearly $10 billion—a 13 percent increase in just one year. Eric Raby, Vice President of Global Marketing and Commercial Development with AGCO, shares his insights on the role of technology and innovation in meeting food system challenges with a special focus on African countries.

Keywords: AGCO, technology, innovation, Africa

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[1] This interview was conducted during the 23rd Annual IFAMA Conference in Atlanta, Georgia, USA, in June 2013.

Can you tell me a little bit about your role as the Vice President of Global Marketing and Commercial Development at AGCO?

I have been with AGCO for 23 years working in a variety of sales and marketing roles in a number of regions including: North America, Western Europe, Eastern Europe, Asia, Africa, and Middle East. I've had the opportunity to see a wide variety of different market places. I have been in my current assignment for just over a year now and basically, my job entails supervising all aspects of global marketing for our company from a corporate perspective. I look after global branding, corporate communication, oversee our key business accounts globally, and also look at establishing financial retail solutions for our customers in emerging markets.

Since the focus of this interview is on technology and innovation, I would like to start by asking you what innovation means to you as an AGCO employee.

First of all, technology and innovation certainly go hand-in-hand and often, when we talk about technology, people think of outer space or they think of computers, or site specific farming—which is true, but it is not the entire picture. From a corporate standpoint, we are focused on introducing and growing the appropriate technology into different markets. So if we look at Africa, there are a lot of corporate or even commercial farming operations that are either underway or are starting up now. Those are going to be the candidates for our technology in terms of broad acre farming— large tractors, large combine harvesters that use satellite guidance, or other specific technology which lower the level of inputs and maximize yields. So, this would be an example of cutting-edge, forward-looking technology that uses a lot of computer systems.

On the other hand, there is huge potential in trying to grow the rural wealth of African nations through smallholder farmers. And in this case, it is really about introducing technological advancements as they relate to what farmers are doing today. So, if I take a smallholder farmer who uses manual labor or animals, and we introduce him to a very low specification basic tractor, this will be a significant advancement in technology for this farmer, even though it doesn't involve satellite guidance or computer programs. Instead, it involves the use of newer technology to solve an existing issue.

Certainly, innovation comes in many different forms. These days, it is really about looking at the whole cycle of everything we do.

Finally, from the standpoint of an employee, innovation means we are always looking for a better way to do things. And that better way is not always how we do things within the company, but also how we help other people do their jobs better, in this case farming.

Where is AGCO present in Africa?

From a sales and after sales support standpoint, AGCO has been present in some African countries, such as Morocco, Tunisia, Libya, Egypt, and South Africa, for a number of years. However, over the last 18 months the company has made a concerted effort to expand its operations on the continent. We just opened a new parts distribution warehouse in Johannesburg, and a new sales office in Cape Town, South Africa. We have also opened a new joint venture manufacturing facility in Constantine, Algeria, and started a new model farm in Zambia. We are one of those companies that when we go into a country, we are going in forever; we plan to be there to provide ongoing support and develop good working relationships. Such an approach requires brick and mortar. It also requires people on the ground. It's not just parachuting people in, but ensuring our innovative products and advanced technology meet the practical needs of the professional farmers who spend every day working on the farm.

AGCO has created and launched a *Global Learning Center* and adjacent Future Farm in Zambia, where farmers are trained in mechanization techniques, equipment operation and agronomy. The facility is also used for training AGCO's African distributors and dealers in all areas of their business to support our growth throughout Africa.

In order to further enhance our presence in Africa, AGCO formed a new joint venture with the Algerian government for the manufacture of tractors for the local domestic market. Also, AGCO and our South African distribution partner, Barloworld, opened a state-of-the-art African Master Parts Distribution Center in Johannesburg, South Africa.

How does AGCO decide on which countries to enter?

Decisions are made to go where opportunities present themselves. We have a long-term strategy, and are concerned with our larger footprint. Ultimately, we would like to have some presence in almost all of the 57 countries in Africa, at least to be able to provide our product and after sales support to customers needing solutions. But from a perspective of a real physical footprint, we must look at the infrastructure that is in place, if there are common monetary systems, language considerations and the unique needs in each country. So we are still in the early stages, but we look for opportunities, and think about how they fit into our longer term plan.

What are the major challenges that you have encountered when introducing new technologies in the developing countries?

Africa is a continent, with 57 different countries. So this is certainly a challenge, because each country has a different set of rules and regulations, different government entities, and different customer types. It creates a lot of variability. There are also a lot of common denominators, and those are the things that we focus on. How can we use our products, our support and apply our knowledge, across a fairly wide geographical area? Again, the major challenge is certainly in the diversity. So, when doing business in Africa, we are not just adding offices in every country, we look at every country strategically and how to grow our presence over time.

The focus of this year's IFAMA meeting was on attracting talented human capital to the food and agricultural sector. In regards to this, how does AGCO *attract* and *educate* talented innovators?

As far as attracting talent, we, for example participate in IFAMA. This is one way. But we also visit a lot of universities during their career days. Additionally, we offer quite intensive online services that connect us with recent or soon to be graduates. We also have an internship program in all our major sites. Our newest class of interns just arrived at our corporate office this week.

Twenty to twenty-five interns will spend the summer with us. We would like some of them to stay with us after they graduate.

We offer two separate programs. The *AGCO Academy* is our school of knowledge for external constituents – our dealers and customers. We have also started some classes for other people to talk about more general topics in agriculture. In these classes we talk about technology, crop rotation, and service training, etc. The other program is the *AGCO University*. This is strictly an internal program, called the *Learning Management System* (LMS). It is a curriculum tailored to the candidate's position and interest level. It's intended to help our employees matriculate through our educational system internally. This program is always evolving and growing.

As the Vice President of Global Marketing and Commercial Development at AGCO, what are your top priorities over the next couple of years when it comes to introducing technology and innovation into Africa?

With the global population projected to rise to more than 9 billion people by 2050, Africa lies at the heart of what promises to be a new Agricultural Revolution and holds the key to ensuring a sustainable food supply. This will only occur if a new roadmap for progress is developed, harnessing both the expertise of the private industry sector and the knowledge of local communities.

Our biggest goal in the short and medium-term is establishing or building upon the presence we have, in a more proactive way, and living in the market. For example, if we take Massey Ferguson, our flagship brand for Africa, we want our customers to know that not only are they buying the product itself, they also receive technical support, repairs, parts and are also eligible for financing. They should know it is an investment, but one with a return. So, it is really about assuring people that when they purchase our products, it will provide value long after the purchase is made. Africa is a capable of ensuring a sustainable food supply. Consequently, we are making the appropriate investments there.

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The IFAMR (ISSN #: 1559-2448)