Landscape Clubs: Co-existence of GM and organic crops

D. A. Dierker
A. S. Weseen
W. H. Furtan

Department of Agricultural Economics
University of Saskatchewan

Abstract

The possibility of increased production of genetically modified (GM) crops in agriculture accentuates the need to examine the feasibility of GM and non-GM technologies coexisting on a single physical landscape. Using the theory of clubs, this paper examines the possibility of co-existence for GM and organic wheat technologies through the formation of an organic club with an exogenously determined buffer zone. Given the available data on prices, yields, and rotations, it is shown that a club can be created in which GM and organic agricultural production technologies can economically co-exist in the same physical landscape. Specifically, co-existence results in an increase in economic welfare over a situation where only GM technology is used but is not Pareto superior because producers in the buffer zone will incur injury. We show that organic producers in the club can compensate producers in the buffer zone and still be better off. Hence, the compensation principle holds. These findings lend support to the notion that, in economic terms, organic and GM technologies need not be exclusive on the same physical landscape, and that club theory may have practical application in a variety of co-existence scenarios.

JEL Classifications: D71 and Q16

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Introduction

Over the past decade, organic agriculture has emerged as a profitable form of farming in North America and Europe. The rapid growth in demand for organic products has shifted organic agriculture from a cottage industry to a significant segment of the agricultural mainstream. Retail sales of organic products in both North America and Europe are estimated to be increasing by 20-25% annually and were valued at approximately 9.5 billion and 10 billion dollars in the two regions, respectively, in the year 2000 (Verschuur and van Well, 2001). In 2003, there are approximately 10,000 organic farmers in North America and acreage is estimated to be 3.3 million acres (Yussefi, 2003).[1]

The co-existence of different production technologies in the same physical landscape is a concern for organic producers.[2] Organic producers are concerned that the release of genetically modified organisms (GMOs) may contaminate organic production. For example, organic wheat producers claim that when GM wheat is released and grown by farmers in the same landscape in which organic production occurs, it may not be possible to keep the two crops separate.[3] If any GM wheat is detected in the organic wheat sample the premium for organic wheat disappears.[4]

Organic crop production prohibits the use of some modern inputs including products such as synthetic pesticides, fertilisers, and genetically engineered seeds (often

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[1] The major organic crops are wheat, corn, soybeans, flax, lentils, peas, forages, and horticulture crops.

[2] This paper examines the issue of co-existence in an economic context. It does not address moral or ethical concerns associated with the co-existence debate.

[3] The term GM crop implies that the crop has some genetic engineering. The precise definition can be found in McHughen (2002).

referred to as genetically modified organisms). Products can only be labelled "certified organic" if all procedures occurring along the supply chain (from crop production to processing) have been verified to comply with established organic standards. Currently, producers of most "certified organic" products are able to obtain a price premium over conventional products of similar type and quality.[5]

To obtain "certified organic" status at the farm level, a crop must have zero GMOs in the sample. [6] This implies that any chemical test of the organic product would be negative for the presence of a GMO. This requirement raises the issue of whether the organic production of an open pollinated field crop, such as wheat or canola, can share a common landscape where varieties of the same crops are produced using GM technologies. For example, in Canada, farmers who produce organic canola claim that the presence of GM canola varieties and the occurrence of genetic drift make it impossible for them to have their organically produced canola certified as organic (Hamm et al. 2002). Such impurities have been known to arise through the mixing of crops during or after harvest (e.g. in combines, granaries, other equipment, etc.), and through the growth of volunteer crops in subsequent years.

The case we examine deals with the production of organic wheat in Canada, however, this same issue is being raised in the European Union (EU), where GM crop

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[4] The term 'sample' refers to a very small quantity of the commodity produced, which is used to grade the commodity. In the case of wheat a 'sample' maybe as little as a quarter of one bushel.

[5] To obtain premiums over conventional crops, organic commodities must be segregated from conventional commodities as they move along the supply chain. Compliance with organic standards (including segregation) is ensured through audit trails. These audits allow buyers at each successive stage of the supply chain to determine the origin of individual products. In cases where crops are exported, regulators in importing countries typically verify organic authenticity through a variety of procedures including an evaluation of the standards employed by the exporter, an inspection of audit trails, and through testing for the presence of banned substances, including GMO's. Contamination of a shipment with banned substances will result in rejection of the shipment, ultimately at the expense of the organic farmer.

production and its impact on organic and conventional production has taken on significant debate (Villalon, 2002). In EU terms, the debate is regarding the ability to maintain GM free crop zones on a regional basis or, given the close proximity of European countries, on a national basis. In essence, this debate is contingent upon whether or not the different production technologies can exist in the same landscape.

We hypothesis it is possible to create an institutional structure where organic and GM crop technologies can co-exist.[7] The co-existence of the technologies can result in an increase in the economic welfare of producers over the situation where only GM technology is employed. To test the hypothesis, we utilize a theoretical model involving the spatial optimization of clubs, first introduced by Casella (1992). In our case, the club is defined on a physical agricultural landscape. Within the club, all crop production is organic (i.e. it is an organic producers club), while outside the club farmers can use either conventional or GM crop technologies. We test the hypothesis using actual farm data for Saskatchewan organic wheat farmers.[8] The results show that given existing premiums, organic wheat producers could form a landscape club, pay the costs associated with operating the club, and still increase their economic welfare.

The paper is organized into six sections. Section two describes how the theory of clubs can be used as a framework to examine the question of crop production technology co-existence. The third section describes the empirical framework, while the fourth

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[6] In this paper we distinguish between organic, conventional and GM production technologies. Organic technology is defined as above. Conventional technology only prohibits the use of GMOs, and GM technology does not prohibit the use of any of inputs.

[7] The notion of co-existence arose because some consumers have concerns regarding the safety of GM products. This paper does not address this issue.

[8] The preferred jurisdiction to study is Canada; however, data on organic wheat production was only available for Saskatchewan.

section describes the data. The fifth and sixth sections of the paper are results and institutional implications, and conclusions respectively.

Theoretical Considerations

A club is a voluntary group of economic agents that collectively derive benefits from sharing one or more of the following; production costs, member characteristics, or a good that has excludable benefits (Cornes and Sandler 1996). Economic literature on the formation of clubs largely focuses on the question of optimal club size as measured by the number of club members (Dixit 2003). Casella (1992) extends the idea to include a measurement of optimal club size in spatial terms.

Following Casella (1992), we define a club as an institution whose members collectively decide how to finance the production of the excludable club good. The spatial or landscape component of the club is the farmland on which organic production is to occur. In our model we have two types of farmers; 1) those who produce organic crops, and 2) those who produce non-organic crops including the use of GM crop technology. The excludable club good is a zoning law that restricts the use of agricultural production technologies (i.e. restricting the use of GM seed varieties).

Consider the interval –1 to 1 along which a continuum of individual farms is uniformly distributed. Along the continuum, each farmer chooses either organic production methods or GM production methods[9], and is characterized by their endowment, x_i. The endowment is an amalgam of their land and production technology. Along the continuum, there are n farmers, i = 1,.., n. Each agent (in our case a farmer) chooses a technology and is then randomly matched to another farmer. If farmers i and j are matched, each of them will have a return y_{ij}, which Casella defines as:

$$y_{ij} = |x_i - x_j|(\beta d - |x_i - x_j|) \qquad (1)$$

where $|x_i - x_j|$ is the Euclidian distance between the two endowments, d is the public good, herein referred to as the club good, and β is a productivity parameter.

Casella demonstrates that for any farmer i, trading with a randomly chosen farmer j, farmer i's ideal partner is located at distance βd/2. Thus, the ideal distance is a function of both the presence and productivity of the club good. The club good is provided by a tax, t, on the members of the club. She then shows that for an exogenously chosen boundary between the groups defined over the intervals [-1, 0] and [0, 1], the expected return for individual i is given by:

$$E(y_i) = \beta_1 d_1(x_i^2 + x_i + ½) - x_i^2 - x_i - 1/3 - t_1 \quad \text{if } x_i \in [-1, 0] \qquad (2),$$

and

$$E(y_i) = \beta_2 d_2(x_i^2 - x_i + ½) - x_i^2 + x_i - 1/3 - t_2 \quad \text{if } x_i \in [0, 1] \qquad (3).$$

This result is derived by making individual $x_{i,}$ at interval point zero, indifferent between the two groups, and then taking the definite integral over the line segment that constitutes the club.

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[9] GM production technologies are used to compare with organic technologies in this case even though conventional wheat technology maybe available. As shown by Furtan et al 2003a conventional and GM wheat technologies also have co-existence problems.

If the club good is provided by a lump sum tax paid by each of the farmers in the club, which in our case are the organic producers, we can then solve for the optimal location of the boundary, labeled σ, between the two groups of producers (Casella 1992). If the location of the boundary is endogenous, it will occur where the expected return of any two farmers immediately on either side of the boundary is equal. That is:

$$E(y_i) = E(y_j)$$

or:

$$\int_{x_j=-1}^{\sigma} |x_i - x_j|(\beta_1 d_1 - |x_i - x_j|)dx_j - t_1 = \int_{x_j=\sigma}^{1} |x_i - x_j|(\beta_2 d_2 - |x_i - x_j|)dx_j - t_2, \qquad (4)$$

which is the point where farmers at the border are indifferent between being part of the organic club and not being a part of it. Assuming that the organic market is market one, and applying Casella's logic, we can manipulate equation (4) and solve for σ, which is implicitly defined by:

$$\beta_1 d_1(1 + \sigma) - \beta_2 d_2(1 - \sigma) + 2(t_2 - t_1) - 8/3\sigma = 0. \qquad (5)$$

The existence of a club good depends, first and foremost, upon the existence of a club. Therefore in this context, when a club good exists d equals 1 and zero otherwise. Similarly, if a club good exists there will be a tax on club members to pay for the good. In the context of this paper, the tax will equal zero if no club exists, and a positive value otherwise. Substituting this information into equation 5 and collecting similar terms yields:

$$\sigma = \beta_1 - 2t_1/(8/3 - \beta_1). \tag{6}$$

Conceptually the optimal boundary, which yields the highest economic welfare between the two groups of farmers, is determined by the efficiency of and level of taxation needed to produce the club good. The efficiency of the club good in our case is represented as the percentage of the available price premium that organic producers receive from the market place. That is, in a full information world, a risk neutral consumer will discount the organic premium they are willing to pay by the likelihood that the organic production has been adulterated by GM varieties. Thus, if all farmers use GM technology, the economic returns will be equal for all farmers and an organic club will not be formed. However, as some consumers are willing to pay a premium for organic products and because the level of production of the organic crop and the corresponding price premium are inversely related, the maximization of producer welfare can result in a situation where both technologies will exist in the same physical landscape.

Empirical Model

The empirical model developed in this paper builds upon the theory described in the previous section to determine if for the maximization of producer welfare an internal boundary point exits that would allow for the co-existence of organic and GM crop technologies. If no internal boundary point exists, then all the land will be used to produce either GM wheat or organic wheat. In such a case, no co-existence problem is present and a club will not be formed. However, if an internal boundary point raises producer welfare, then some institutional arrangement needs to be developed that will allow for the co-existence of the two production technologies to exist in the same physical landscape.

First, we assume that farmers who produce GM wheat face a perfectly elastic demand. As our data refers to wheat production in Saskatchewan, this is not a strong assumption.[10] Second, we assume the demand curve facing organic wheat producers is price inelastic (Furtan et al 2003b). Saskatchewan is the major Canadian producer of high quality (high protein) organic wheat (i.e. over 90 percent of the total Canadian organic wheat production). Finally, we use a farm-planning model (budget model) to determine the returns per acre resulting from each wheat technology.

In figure 1, the optimal border point σ, is determined by the intersection of the aggregate rotation-profit functions of organic and GM wheat producers. A rotation-profit function is the discounted per acre profit that occurs on one acre of farmland for the entire rotation cycle. It should be noted that aggregate rotation-profit function for both organic and GM farmers are determined by evaluating entire crop rotations and wheat is only one crop in each rotation.

The profit per acre for each crop (we assume each acre of land has the same yield for the same crop, however different crops have different yields per acre) within the organic and GM wheat rotation can be written as:

$$\pi^0 = P^0(g^0(\beta_1),t_1)g^0 - C^0(g^0(\beta_1)), \text{ and} \qquad (5)$$

$$\pi^{GM} = P^{GM}g^{GM} - C^{GM}(g^{GM}) \qquad (6)$$

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[10] In 2003 Saskatchewan farmers planted approximately 10 million acres of spring wheat.

where π^0 and π^{GM} are the per acre profits generated using the organic and GM technologies within their specific crop rotations, $P^0(g^0(\beta_1),t_1)$ is the demand curve for the bundle of organic crops that the organic rotation yields, g^0 is the quantity of the organic crop produced by the same rotation, P^{GM} is the price of crops produced in the GM bundle, g^{GM} is the quantity of crops produced by the GM rotation, $C^0(g^0(\beta_1))$ is the cost of producing one acre of the organic rotation, and $C^{GM}(g^{GM})$ is the cost of producing one acre of the GM rotation.[11] The cost of production is different between the organic and GM wheat (Furtan et al 2003a), as the production of GM wheat permits the use of chemicals to control weeds and fertilizers not available to organic farmers.

The profit per acre for each crop is converted into a rotation-profit function. We take a three-year rotation for GM wheat production including an oilseed and a pulse crop (we convert the three-year GM wheat rotation to a ten-year rotation to make it compatible with the organic rotation as shown in the next section of this paper). The calculations for each crop are as shown in equation 6. For organic producers, we use a ten-year rotation. As organic wheat acreage is expanded, the price of organic wheat declines; all other prices are held constant. The profits for each rotation are discounted. The rotation data used in the empirical model is given in the next section of this paper.

The solution, σ, to the co-existence hypothesis is shown in figure 1 at the intersection of the two rotation-profit curves. At this intersection, the returns per acre earned for each technology are equal. Hence, at this point a producer is indifferent between the two technologies. As shown in figure 1, the maximum producer welfare is achieved with the co-existence of both technologies in a common physical landscape.

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[11] There is a one-to-one correspondence between acres and bushels in this paper. We refer to each when required by the model specification.

The price of organic wheat depends upon the efficiency of the club good β_1 and the tax on organic wheat producers, t_1, which is required to produce the club good. For example, when $\beta_1=0$, organic wheat will not be produced because the club cannot keep organic wheat separate from GM wheat. If $0< \beta_1<1$, a portion of each organic bushel produced will earn an organic premium[12], and if $\beta_1=1$, all wheat produced earns an organic premium (i.e. $\delta\pi/\delta\beta_1< 0$, for $0 \leq \beta_1\leq 1$). The club tax, t_1, will be a per acre tariff on organic farmers and shifts the organic profit function accordingly (i.e. $\delta\pi/\delta t_1< 0$).

If a buffer zone is required between the organic and GM production sites, farmers in the buffer zone will produce all the same crops, except GM wheat, that are used in the GM rotation. These farmers will, however, use chemicals and fertilizers available to GM producers. That is, farmers will use organic wheat varieties with conventional technology. Wheat produced in the buffer zone may have some GM contamination and will receive the GM market price (Furtan et al. 2003a). The profit per acre for this group of farmers can be written as:

$$\pi^C = P^{GM}g^C - C^C(g^C) \qquad (7)$$

where g^C is the quantity of the crops produced in the conventional rotation, and $C^C(g^C)$ is the per acre cost of production using conventional technology.

The profitability of conventional technology will be less than the profitability of GM technology because of the lower GM market price and the higher cost of conventional production (Furtan et al 2003a). For any farmer to voluntarily participate in

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[12] This general example does not assume a zero tolerance policy.

this group, they will have to be compensated such that they are indifferent between being a wheat producer in the buffer zone and being a GM producer outside the buffer zone. The solution to this problem is shown in figure 2.

The creation of a buffer zone, which separates the two crops, as in figure 2 may result in a reduction of both the organic and GM acreage. Because organic farmers must compensate the farmers in the buffer zone, there must be sufficient producer income generated from organic wheat production to compensate the losers in the buffer zone and still leave the organic producers better off. In the case where some adulteration of the club crop is allowed (for example if organic wheat had a tolerance level different than zero) the club producers may reduce their acreage and raise the premium just enough to pay for the compensation. This would be the case when the size of the buffer zone is determined endogenously. However, in the case of organic production, no adulteration is allowed; thus organic producers will compensate producers in the buffer zone from the revenue they generate and all the land in the buffer zone will be taken from GM wheat acres.

In figure 2, the loss of income for wheat farmers in the buffer zone is equivalent to area *acdb*. Organic farmers will need to raise additional revenues (i.e. additional to the tax t_1) through a per acre tax, t_c, to compensate this loss. The tax, t_c, is the distance *fg* so that area *fgex* is just equal to area *acdb*. This model allows us to test the hypothesis that an organic club can be formed that earns a market premium over GM wheat, compensates the losers in the buffer zone, and increases economic welfare over the case where only GM wheat is produced. It is important to notice that government subsidies are not required to achieve the solution.

Data

The data used to create the rotation-profit functions for organic, conventional, and GM wheat in the empirical model comes primarily from crop budgets reported by Agriculture and Agri-food Canada (2000) and Alberta Agriculture (2001). The GM wheat budget is adopted from Holzman (2000). The crop budgets for organic, conventional, and GM technologies are presented in table 1. The budgets are presented in dollars per acre and are directly dependant on yield (bu/acre), cost (\$/bu), and price (\$/bu). It should also be noted that we assume no price change for any commodities produced during the 10-year rotation.

The construction of the rotation-profit functions used in our empirical analysis involves calculating net present values[13] for each of the three 10-year[14] budgets presented above. The formula for net present value can be expressed as:

$$\mathrm{NPV} = \Sigma\ \pi/(1+r)^n \qquad (8)$$

where π is the annual profits (revenue minus costs) for each budget, r is the discount rate, and n is the number of years (or periods). For the purpose of this analysis, we have assumed a discount rate of 7%. In each budget, the present values of profit for each year are summed to obtain the net present value for each rotation. The net present

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[13] Net present value can be defined as the discounted value of future profits in each of the budgets described above. The further into the future that profits are earned, the more they have to be discounted to accurately reflect their present value.

[14] The profitability of each farming technology cannot be measured accurately over a one-year period and is therefore calculated over 10 years. This also allows the analysis to include the 3-year transition period, required of organic farmers, where organic practices are undertaken but premiums for organic commodities

values calculated for organic, conventional, and GM rotations over ten years are \$151.71/acre, \$144.41/acre and \$139.20/acre, respectively.

The final step in calculating the rotation-profit functions involves constructing demand curves for organic, conventional and GM wheat. We determine the change in profits (or the change in NPV) that result from a change in the quantity of wheat produced for each technology within each rotation. In the case of GM and conventional wheat, we assume a perfectly elastic demand curve because Saskatchewan is a price taker in world markets. The result is that, regardless of the quantity of GM or conventional wheat produced, the profits per acre will remain unchanged. This is indicated by the flat rotation-profit function for GM and conventional wheat production in figure 2.

To construct a demand curve for organic wheat, we use organic wheat production and premiums from Hamm (2002), and the domestic wheat elasticity reported in Furtan et al (2003). We estimate organic wheat prices for 2001 by adding the premium earned by producers on organic wheat production reported by Hamm (2002) to the average Canadian Wheat Board Pool return to Saskatchewan farmers. Using this constructed organic wheat price, Hamm's organic wheat production estimates, and a price elasticity of –0.15, we estimate the organic wheat demand curve. This elasticity is then used to estimate a complete demand curve for organic wheat. (The price elasticity of demand is -0.078 at the 2001 production level.) Having constructed this demand curve, we can then determine how the profitability of organic farming is affected by changes in the quantity of organic wheat grown.

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are unavailable. The study does not look beyond 10 years, as the volatility of organic and conventional markets would make it difficult to forecast beyond this length of time.

Empirical Analysis

To find the point that determines the optimal size of the organic club given an exogenously imposed buffer zone, we maximize the net present value from both organic and GM wheat production subject to two constraints. First, the tax on organic farmers (*fgex*) is equal to the loss incurred by farmers in the buffer zone (*acdb*). Second, the net present value for the organic rotation must equal the net present value of the GM rotation. The solution to this problem gives the value for σ in figure 2.

The exogenous buffer zone was set at 400 meters based on Canadian Food Inspection Agency (2000) regulations that suggest that the maximum buffer zone required for any crop with novel traits is 400 meters.[15] This distance is required in addition to a set of specific post harvest restrictions referring to agronomic actions that the farmer must follow on the land within the buffer zone. For example, if a farmer is growing a crop with novel traits, he must remove all volunteers of that crop in the buffer zone for a period of five years.

The model was also solved using a second buffer zone of 300 meters width. Hucl and Matus-Cadiz (2001) report that the buffer-distance recommended for crops with high out-crossing rates is 30 meters. Because we are examining a ten-year rotation, we increase the buffer distance by a factor of ten, which provides a new buffer distance for each of the years of the rotation. This provides reasonable assurance that the organic wheat will not be contaminated by the GM wheat production.

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[15] Each province may have a different maximum distance depending upon the crops grown in that province. Because we use Saskatchewan data in our model, and Saskatchewan is the major organic wheat-producing province in Canada, the most restrictive distance is for Polish canola. In Alberta the most restrictive distance is 600 meters for sugar beets.

Acreage of organic and GM wheat production, the size of the buffer zone and the corresponding profit are reported at table 2. If no organic crops are grown on the landscape, total profits from crop production are $4941.7 million. If both organic and GM wheat are produced, the intersection of the two rotation-profit functions occur at an interior point. In this case, total crop profits increase to $5527.3 million (shown in row 2 of table 2). Of this total, profits from organic crop production are $697.5 million, while profits from GM production are $4829.8 million. The solution indicates that the maximum producer welfare occurs at 160,600 acres of organic wheat production, which is very close to the 2001 actual acreage of 180,000 acres reported by Hamm (2002).[16] This result indicates that allowing for both production technologies to exist in a common landscape can increase producer welfare.

In the case where we introduce an exogenous buffer zone of 400 meters and wheat produced (using conventional technology) in the buffer zone receives the GM wheat price, the non-organic crop profits decline slightly to $4829.54 million (shown in row 3 of table 2). The reason for this decline is that farmers in the buffer zone experience a decline in income of approximately $250,000, which is paid for by farmers in the organic wheat club. After the organic farmers compensate the wheat farmers in the buffer zone for the loss they (the organic producers) are still better off and the farmers in the buffer zone no worse off, than the case where only GM wheat was grown. Thus the compensation principle is satisfied.

When the size of the buffer zone is reduced from 400 to 300 meters the total profit from non-organic production increases from $4829.54 to $4829.61 million (row 4 of table 2). In this case, the level of compensation paid by the organic producers to the

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[16] The last data available on organic wheat acreage in Saskatchewan was for the year 2001.

farmers in the buffer zone declines to $180,000. This result indicates that the size of the buffer zone (at least the sizes used in this study which are on the high side) does not impact the magnitude of the results of the empirical model.

There are two strong conclusions that can be drawn from table 2. First, by allowing both organic and GM wheat production to occur in the same landscape, economic welfare of crop producers is increased by more than ten percent over the case where only GM wheat is produced. This conclusion rests on the ability of organic producers to form a club. However, the formation of the club is not a Pareto superior move because of economic injury to those producers in the buffer zone. The second conclusion from table 2 is that the gainers from the formation of the club can compensate the losers who are in the buffer zone, and still be better off economically, therefore satisfying the compensation principle.

Sensitivity Analysis

A sensitivity analysis was conducted on the price elasticity of demand for organic wheat. As the demand curve for organic wheat becomes more inelastic, the profits accruing to organic production increase, as shown in table 3. Likewise when the demand curve becomes more elastic, the profits decline. The acreage changes associated with the change in demand elasticity are small (see table 3), indicating that our solution is not sensitive to the demand elasticity. A large part of the reason for this stability is that wheat only makes up 20 percent of the ten-year organic rotation.

Institutional Implications

In the absence of a club GM wheat production creates a negative externality on organic wheat producers when both crops are grown in a common landscape. Because of the zero tolerance policy for GMOs in an organic wheat sample, the negative externality may be sufficiently large to make organic wheat production infeasible. This negative externality can be removed through the formation of an organic wheat producers club. However, the formation of a welfare-enhancing club may require government facilitation.

Although landscape clubs are typically only hypothesised in a theoretical capacity, the notion of creating one in practice is not as uncommon as one might think. For example in the 1960s, rural municipalities in Saskatchewan passed zoning bylaws that restricted the use of certain production technologies. Rapeseed and mustard, both of the family *brassica,* are open pollinated crops. When grown in the same landscape with the potential for cross-pollination to occur, mustard crops were rendered to be of little value if they were contaminated with low quantities of rapeseed. This occurred because it is impossible in a post harvest operation to separate rapeseed and mustard (i.e. the seeds are the same size and weight thus can not be separated using seed separation screens). In order to keep the production separate a rural municipality would decide to produce either mustard or rapeseed, but not both. The zoning bylaw was monitored and enforced by the municipality. Although these bylaws are no longer in effect, this example illustrates that it is feasible to set up clubs that restrict the type of technologies used within a landscape.

Conclusion

The current debate over GM and organic technologies in Canada is typically precluded by the notion that co-existence is not an economically or agronomically viable alternative to the exclusion of one of the two technologies. Examining the economic feasibility only, we have demonstrated that it is possible to create an institutional structure or club through which organic and GM production technologies can co-exist on the same physical landscape. In the case examined here, co-existence will result in an increase in economic welfare over a situation where only GM technology is used. Although the club is welfare enhancing for wheat producers as whole, it is not Pareto superior because producers in the buffer zone will incur injury. However, organic producers in the club can compensate producers in the buffer zone and still be better off. These findings lend support to the notion that, in economic terms, organic and GM technologies need not be exclusive on the same physical landscape.

As it relates to co-existence in general, our study further shows that the theory of clubs when presented in a spatial context can be directly applied to a variety of identifiable co-existence issues in which negative market externalities are present. Among these issues are the debate over GM and non-GM production in Europe and nations outside of Europe, issues of water and air pollution, and a multitude of other environmental problems. Applying club theory to these problems in a manner similar to that employed here would be one way to account for externalities that are rarely considered when making policy decisions.

References

Agriculture and Agri-Food Canada, **2000.** "Organic Grains and Oil Seeds." Bi-weekly Bulletin, vol. 13 no. 5: March 16, Ottawa, Ontario.

Alberta Agriculture Food and Rural Development. 2001. "Agriculture Business Profiles." Ag-Ventues, Agdex 100/830-1: September, Edmonton, Alberta.

Canadian Food Inspection Agencies. 2000. Regulatory Directive 2000-07: Guidelines for the Environmental Release of Plants with Novel Traits within Confined Field Trials in Canada. Appendix 2: Minimum Isolation Distances and Periods of Post Harvest Restrictions, Ottawa, Ontario.

Casella, A. 1992. "On Markets and Clubs: Economic and Political Integration of Regions with Unequal Productivity." *AEA Papers and Proceedings*. Vol. 82, no. 2, pp.115–121.

Cornes, R. and T. Sandler. 1996. *The Theory of Externalities, Public Goods and Club Goods.* Cambridge: Cambridge University Press) 2nd ed.

Dixit, A. 2003. "Clubs with Entrapment." *American Economic Review*. Vol. 93, No. 5, pp. 1825–1829.

Furtan, W. H., R. S. Gray, J. J. Holzman. **2003a.** "The Optimal Time to License a Biotech "Lemon." *Contemporary Economic Policy*. Vol. 21, no. 4, pp. 433–444.

Furtan, W. H., R. S. Gray, J. J. Holzman. 2003b. "Regulatory Approval Decisions in the Presence of Market Externalities: The Case of Genetically Modified Wheat." University of Saskatchewan Department of Agricultural Economics Working Papers, Saskatoon, Canada.

Hamm, J. W., B. J. S. Hamm and J. Linfrield. 2002. "A Preliminary Assessment of the Economic Impact of Genetically Engineered Canola and Wheat Introduction on Saskatchewan Organic Grain Farmers", Exhibit B to the Affidavit of J. Wallace Hamm in QB 67 of 2002 in the Judicial Centre of Saskatoon, Canada.

Hucl, P. and M. Matus-Cadiz. 2001. "Isolation Distances for Minimizing Out-crossing in Sprig Wheat. Crop Science, Vol. 41, pp. 1348-1351.

McHughen, A. 2000. *Pandora's Picnic Basket, The Potential and Hazards of Genetically Modified Foods.* Oxford: Oxford University Press, United Kingdom.

Verschuur, G. W. and E. A. P. van Well. 2001. "Stimulating organic farming in the EU with economic and fiscal instruments." Utrecht: Centre for Agriculture and Environment.

Villalon, N. A. 2003. "New legislation on GMOs in Europe and how it may affect organic production." Organic Standard Issue 30: October, pp10-13.

Yussefi, M. 2003. "Development and State of Organic Agriculture World-wide." in The World of Organic Agriculture 2003 – Statistics and Future Prospects, Minou Yussefi and Helga Willer (editors).

Table 1: Crop Budgets for Organic, Conventional and GM Technologies

	Organic		***Conventional***		***GMO***	
	Rotation	**Net Revenue ($/acre)**	**Rotation**	**Net Revenue ($/acre)**	**Rotation**	**Net Revenue ($/acre)**
Year 1	Clover (no rev)	$ (22.26)	Wheat	$ 19.02	Wheat	$ 15.86
Year 2	Clover (rev)	$ 10.00	Canola	$ 18.21	Canola	$ 18.21
Year 3	Clover (rev)	$ 10.00	Barley	$ 30.35	Barley	$ 30.35
Year 4	Flax	$ 37.84	Peas	$ 25.50	Peas	$ 25.50
Year 5	Peas	$ 40.27	Wheat	$ 19.02	Wheat	$ 15.86
Year 6	Wheat	$ 49.43	Canola	$ 18.21	Canola	$ 18.21
Year 7	Clover (rev)	$ 10.00	Oats	$ 1.01	Oats	$ 1.01
Year 8	Flax	$ 37.84	Peas	$ 25.50	Peas	$ 25.50
Year 9	Peas	$ 40.27	Canola	$ 18.21	Canola	$ 18.21
Year 10	Wheat	$ 49.43	Barley	$ 30.35	Barley	$ 30.35

Source: Agriculture and Agri-food Canada (2001) and Holzman (2000).

Table 2: Comparison of profits and acreage for a 0, 300 and 400 meter buffer zone.

Wheat Technologies in the Landscape	*Total Profit from Organic Production*[1]	*Total Profit from Non-Organic Production*[2]	*Compensation from organic producers to buffer*	*Total Profit from Crop Production*	*Organic Wheat Acreage*	*Total Organic Club Acreage*	*Total Non-Organic Acreage*
	($ 000 000)	($ 000 000)	($ 000 000)	($ 000 000)	(acres)	(acres)	(acres)
No Organic	0	4941.7		4941.7	0	0	35500000
GM and Organic (no buffer)	697.5	4829.8		5527.3	160600	803200	34696800
GM and Organic (exogenous buffer of 400 meters)	697.5	4829.54	0.25	5527.3	160600	803200	34696800
GM and Organic (exogenous buffer of 300 meters)	697.5	4829.61	0.18	5527.3	160600	803200	34696800

1. Total profit from organic production includes compensation to be paid to producers in the buffer zone.
2. Total profit from non-organic production excludes compensation to be received from producers in the club.

Source: Author's calculations

Table 3: Sensitivity Analysis on the Elasticity of Demand with no buffer zone

Price Elasticity of Organic Wheat Demand	*Change in Organic Wheat Acres*	*Total Profit from Organic Production*	*Total Profit from Non-Organic Production*	*Total Profit from Crop Production*
	(acres)	(000,000)	(000,000)	(000,000)
-0.1	2220	568.5	4829.5	5398
-0.078	0	697.5	4829.8	5527.3
-0.05	-2960	1012.5	4830.2	5842.7

Source: Author's calculations

Figure 1: Optimal organic club area

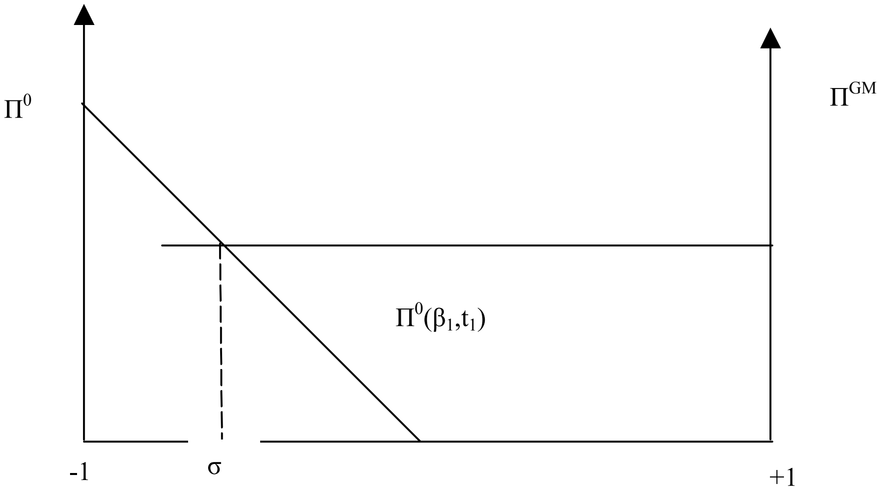

Figure 2: Optimal club size with a buffer area