

The Impacts of the Canadian Wheat Board Ruling on the North American Malt Barley Markets

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The 2011 Marketing Freedom for Grain Farmers Act deregulated Canadian grain markets and removed the Canadian Wheat Board (CWB) as the sole buyer and seller of Canadian grain. We develop a rational expectations contract decision model that serves as the basis for an empirically informed simulation analysis of malt barley contracting opportunities between Canadian farmers and U.S. maltsters in the deregulated environment. Comparative statics and simulation results indicate that some new opportunities for contracting are possible, but the likelihood of favorable conditions for U.S. maltsters to contract with Canadian rather than U.S. farmers is low—between 9% and 35% over a range of possible selection rates. The effects on contracting of the termination of the Canadian grain transportation revenue cap policy and of the relaxation of criteria for the release of new spring wheat varieties are also investigated. While changes to grain transportation policies are not likely to significantly affect favorable conditions for contracting, reducing constraints on Canadian farmers' access to higher yielding wheat varieties could increase the returns from growing spring wheat but decrease the likelihood of contracting for malt barley with U.S. maltsters by an average of 5.3 percentage points.

L'adoption de la Loi sur le libre choix des producteurs de grains en matière de commercialisation en 2011 a déréglementé les marchés canadiens des grains et a délogé la Commission canadienne du blé (CCB) en tant que guichet unique pour la commercialisation des grains canadiens. Nous avons élaboré un modèle de décisions de passation de marché fondé sur des anticipations rationnelles comme modèle de base pour l'analyse par simulation des occasions de passation de marché pour l'orge brassicole entre les céréaliculteurs canadiens et les malteries étatsuniennes dans le contexte de la déréglementation. Selon les résultats de la statique comparative et de l'analyse par simulation, de nouvelles occasions de passation de marché sont possibles, mais la probabilité que les malteries étatsuniennes jouissent de conditions favorables pour conclure des marchés avec des céréaliculteurs canadiens plutôt qu'avec des céréaliculteurs étatsuniens est faible et varie de 9 à 35 % pour des taux de sélection probables. Nous avons également examiné les répercussions de l'abolition de la politique de plafond de revenu du transport du grain de l'Ouest sur la passation de marché ainsi que les répercussions de l'assouplissement des critères quant à l'accès à de nouvelles variétés de blé de printemps. Alors que les modifications apportées à la politique de transport du grain ne devraient pas influencer de façon significative les conditions favorables à la passation de marché, la réduction des contraintes d'accès des céréaliculteurs canadiens à des variétés de blé à rendement élevé pourrait accroître les revenus tirés de la culture du

blé de printemps mais également diminuer la possibilité de conclure des marchés pour l'orge brassicole avec des malteries étatsunienne d'environ 5,3 points de pourcentage.

INTRODUCTION

Market failure is often cited as a rationale for government intervention, but as Wolf (1979) has argued, public policy can also create economic distortions in the form of nonmarket failures. Earlier, Coase (1964) famously reasoned that policy interventions can, in some instances, be inefficient and wasteful. For example, as noted by Niskanen (1968), such nonmarket failures could arise through the creation of public or quasi-public agencies that pursue their own interests at the expense of a greater public interest. Coase (1964) argued therefore that the criteria for evaluating changes to public policy should not be based on whether the changes are optimal (a first-best solution in the traditional economic welfare paradigm), but an improvement over the existing state of the world. The question we examine in this study is whether the disestablishment of the Canadian Wheat Board (CWB), a Crown Corporation, as a single-desk buyer and seller of malt barley affects the development of contracting for the delivery of malt barley between large U.S. malting companies and prairie province farmers and the aggregate benefits from such contracting to these parties. This issue falls firmly within the domain of economic policy questions that both Coase and Wolf believe are important.

Government policies, agencies, and regulations have shaped many national food and agricultural systems and have had important impacts on international markets. In the Canadian prairie provinces, the CWB has had a major effect on the structure of agriculture for over 70 years through the use of its single-desk monopsony and monopoly powers to purchase and market malting barley and wheat for human consumption and export. The CWB's single-desk authority has constrained farmers' marketing opportunities, affected prices through price pooling, has been viewed as limiting varietal choice, and has had important impacts on crop mix and production decisions.¹ The CWB's single-desk authorities, policies, and day-to-day operations also had substantial impacts on the structure of the Canadian grain acquisition, transportation, and processing industries and affected international trade and trade relations, perhaps especially between Canada and the United States. In December 2011, the Canadian government decided to terminate the CWB's single-desk authority, allowing farmers to market their own wheat and malting barley. This decision is likely to have important short- and long-term economic effects on the production, marketing, and export of grain and oilseed in the prairie provinces.

Previous studies of government sanctioned state trading enterprises (STEs) such as the CWB have mainly focused on modeling and quantifying their welfare effects and other potential distortions in trade and the efficiency of marketing services, market power, and food security. These analyses provide mixed evidence about the effects of STEs (and the CWB) on economic efficiency, standard measures of economic welfare, and benefits to

¹ Veeman (1993) has cautioned that the Canadian Grain Commission's varietal licensing decisions with respect to malting barley should not be inferred to be the result of CWB's activities. However, Ulrich et al (1987) argued that varietal control restricted production decisions and, among others, Carter et al (1998) provide some evidence that the CWB lobbied for varietal restrictions with respect to small grains.

stakeholders (e.g., see Veeman 1987; Alston et al 1993; Carter et al 1998; Alston and Gray 2000; Carter and Smith 2001; Lavoie 2005; McCorrison and MacLaren 2006; Tamini et al 2010). More broadly, the effects of removing long-standing agricultural policies has been a subject of numerous studies, including those that have examined the deregulation of the Australian dairy industry, regulatory reform of New Zealand's beef and sheep sectors, and the end of tobacco production and price management in the United States (e.g., see Sureshwaran et al 1990; Doucouliagos and Hone 2000; Paul et al 2000; Edwards 2003; Brown et al 2007). However, the impacts of disestablishing government-sanctioned programs and expanding options for the use of alternative marketing channels on contracting decisions by market participants have not been extensively studied.

This study provides a positive, empirical economic analysis of the potential multi-faceted effects of the 2011 *Marketing Freedom for Grain Farmers Act*, which deregulated the marketing and procurement of Canadian malt barley and altered the incentives for contracting between Canadian farmers and U.S. brewers for the production and delivery of malting barley. The new legislation enabled malt barley consumers, primarily large beer brewers in Canada and the United States, to contract directly for malting barley with farmers in Alberta, Manitoba, and Saskatchewan, avoiding the transactions costs associated with having to work through the CWB in its role as a marketing intermediary. We analyze the potential for malt barley contracting between Canadian barley producers and U.S. malting and brewing companies (maltsters) in the absence of a CWB with single-desk authorities.²

The analysis addresses three important questions. First, how does the termination of the CWB's single-desk authority affect a Canadian farmer's contracting decisions? Second, what are the effects of the termination of the CWB's single-desk authority on U.S. maltsters' decisions to contract with Canadian or U.S. barley producers? Third, what market conditions are necessary to create incentives for Canadian farmers to establish contracts with two major U.S. malt barley procurers, MillerCoors, LLC and Anheuser-Busch Companies, LLC, for malt barley delivery to U.S. malting facilities?³

² Buschena and Gray (1999) show that when constraints on trade between Canada and the United States were lowered as a result of the Canada/U.S. Trade Agreement, several mergers occurred among malting barley companies. In this study, we do not investigate incentives for mergers between U.S. and Canadian maltsters or by companies within each country as a consequence of the termination of the CWB's single-desk authority.

³ MillerCoors and Anheuser-Busch account for 70% of U.S. beer production, all of which is located in facilities within the United States. In 2008, InBev acquired Anheuser-Busch to form AB InBev, which is headquartered in Belgium. This joint company also controls the Labatt Brewing Company, which, together with Molson Coors, produces approximately 85% of Canadian beer. In this market setting, both MillerCoors and AB InBev may attempt to exercise market power both in the final product market for beer and in input markets. Empirical evidence for oligopoly power in brewery markets is limited. The studies that do exist report mixed results about the impacts of increased concentration on market power (Denney et al 2002; Tremblay and Tremblay 2005) and increased industry profits (McCafferty and Bhuyan 2012). Buschena and Gray (1999) show that a deregulated trade environment between Canada and the United States would result in net benefits to beer consumers, even though these benefits could be dampened by brewery mergers. However, theoretical or empirical evidence of oligopsony effects in the brewing industry is largely absent. We assume that because farmers have the option of raising crops other than malt barley, the extent to which

We develop a formal rational expectations contract decision model that serves as the basis for an empirically informed simulation analysis of the feasibility of contracting for malt barley between Canadian farmers and U.S. maltsters in the deregulated environment. While the focus of the model is on the potential for Canadian farmers to contract with U.S. maltsters, those farmers could (and would) also contract with Canadian malting facilities. That is, malt barley contracting can occur independently and concurrently with either or both U.S. and Canadian maltsters, because we assume that there is enough land to meet contracting requirements in both countries, even if those contracts have different prices.⁴ At the margin, farmers make decisions about whether to plant malt barley or spring wheat and as we show, contracting with U.S. maltsters depends on whether the contract price offered to Canadian farmers provides returns in excess of those available from marketing alternative crops.

The simulation model therefore is calibrated using historical Canadian and U.S. crop yield, price, and transportation cost data and used to consider a wide range of alternative assumptions about farmers' and maltsters' *ex ante* expectations of important variables. These include selection rates (the frequency with which malting barley crops will meet contract specific malting standards), malt barley yields and malt and feed barley prices, yields and prices for spring wheat (assumed to be the competing crop), and transportation costs. To ensure that the simulation analysis reflects historical relationships between spatial and cross-commodity yields and prices, we estimate empirical correlations among the price and yield variables and specify a copula function to simulate from a multivariate probability distribution. As such, this study adds to the emerging body of work that uses copula functions to model the complexities of agricultural markets and provide more informed analyses of policy interventions.

The base case simulation assumes that while Canadian grain producers form expectations based on historical barley and wheat price distributions, the CWB's single-desk authority no longer constrains their opportunities to contract with U.S. maltsters. We also use the simulation model to investigate the impacts of other potential policy changes, including the termination of the rail transportation revenue caps imposed by the 1996 *Canadian Transportation Act* and the relaxation of criteria used in determining whether new crop varieties should be released such as kernel visual distinguishability (KVD) as historically applied to spring wheat. The CWB argued that this criterion was useful in creating a unique brand for Canadian wheat exports, and the criterion may continue to be applied by the Canadian Grains Commission (CGC). The KVD and other CGC criteria have likely adversely affected spring wheat yields in the prairie provinces by constraining western Canadian farmers' access to higher yielding varieties of wheat (Ulrich et al 1987).

Empirical results indicate that some malt barley contracting opportunities would exist for farmers in all three prairie provinces under a deregulated marketing structure, suggesting that the CWB may have limited profit maximizing opportunities in North

monopsony market power in the input market can be exercised is limited. Moreover, we assess the opportunity costs to farmers and feasibility of contracting in terms of those alternative cropping decisions. The results therefore are not contingent on the market structure assumptions.

⁴ In practice, this assumption is reasonable because malt barley varieties compete for land with either spring wheat or feed barley varieties, which are planted much more extensively than malting barley in the prairie provinces.

American grain markets. Generally, contracting with U.S. maltsters is most likely to take place in Manitoba, followed by Saskatchewan and Alberta. The major factors affecting contracting conditions are *ex ante* expectations about barley selection rates, spring wheat yields, and transportation costs. Higher expected selection rates raise the opportunity costs of producing competing crops and increase Canadian farmers' incentives to contract for barley production, while higher spring wheat yields increase their opportunity costs of producing malt barley. Increases in Canadian rail freight rates for grain lower U.S. maltsters' contracting incentives. For example, we show that relative to farmers in Alberta, producers in Saskatchewan and Manitoba are expected to be 4–18 percentage points more likely to contract because they are geographically closer to the U.S. brewers.

The results also indicate that higher Canadian grain freight rates, associated with freight rate deregulation, may only have minimal effects on contracting incentives. The reason is that the distance from Canadian farms producing malt barley to the U.S.–Canadian border is small relative to the distance from the border to the plants at which U.S. maltsters would take delivery of the grain. In contrast, relaxing controls over the release of new spring wheat varieties, which could result in the adoption of higher yielding varieties currently grown in the United States, would reduce the probability that Canadian farms would contract with U.S. maltsters by as much as 11 percentage points. These results provide new insights about the complex relationships between government policies and agricultural market outcomes, especially when those policies restrict marketing opportunities and constrain production management decisions.

THE CHANGING POLICY ENVIRONMENT

The contemporary version of the CWB has its roots in the mid-1930s. The CWB was given the authority in the 1940s to be a single-desk purchaser and marketer of malt barley and wheat from the prairie provinces, both for domestic human consumption and for all exports of malting barley and wheat. In December 2011, the Conservative Party of Canada, whose platform partly focused on market deregulation, succeeded in obtaining legislation to end the CWB's single-desk authorities, which went into effect on August 1, 2012. This represented a major change in how North American malting barley and wheat markets could function and is likely to have important impacts on market participants and Canadian grain exports. However, the full impacts of this change are currently not fully understood, including the potential impacts on contracting for the delivery of malt barley between prairie province farmers and U.S. maltsters.

While the CWB had a central role in Canadian grain markets, other Canadian federal government agencies and legislative initiatives are also important and likely to remain influential. Two are especially relevant: the 1996 *Canadian Transportation Act* and the CGC. The 1996 *Canadian Transportation Act*, which replaced earlier 1983 legislation that directly appropriated federal funds to subsidize grain transportation, imposed annual grain transportation revenue caps for rail companies.⁵ Since 2001, the Canadian National Railway and the Canadian Pacific Railway, companies affected by the rate cap, have exceeded these caps on a total of nine occasions, although never by more than 10%

⁵ The 1983 *Western Grain Transportation Act* imposed rate regulations and, in turn, subsidized Canadian rail companies.

(Western Grain Revenue Cap Statistics 2011), suggesting that the policy has been binding. Its removal therefore could affect marketing decisions and opportunities, especially if the resulting higher rail rates alter grain procurers' marginal transaction costs.

The 1985 *Canada Grain Act*, the most recent legislation providing authority to the CGC (originally established in 1912), broadly stipulates that the CGC is responsible for overseeing grain quality and grain handling services. This includes determining grain standards and grades, weighing and inspecting grain, and researching the quality of new grain varieties before the seeds can be registered and sold to Canadian farmers. The CGC's role in variety development and approval for release was especially important when the CWB was the sole marketer and exporter of Canadian grains, because the CWB used strict varietal control standards to differentiate and market Canadian wheat and barley in export markets. If the CGC continues to restrict access to new, potentially higher yielding varieties of barley and wheat through the use of criteria such as KVD, then farmers may forgo substantial revenue opportunities. Grain consumers who may have preferences to acquire grains that are produced from customized seeds would also be affected. Accounting for the impacts of CGC policies and transportation regulations after the termination of the CWB's single-desk authority is central to understanding how the framework within which malt barley markets will function under alternative policy structures.

A CONTRACTING MODEL FOR MALT BARLEY

Contracting occurs when all parties to a contract expect to benefit from that contract. In this context, the parties are western Canadian farmers and U.S. maltsters, each of which is assumed to form expectations rationally and to be risk neutral. Farmers are assumed to know the joint distributions of crop prices and yields and can therefore rationally forecast the distributions of the conditions under which the farm will be willing to contract with maltsters. Maltsters also know those joint distributions as well as the distribution of transportation costs associated with shipping barley from the farm to the malting plant. In this context, both farmers and maltsters can rationally forecast the frequency with which contracting is likely to occur, but cannot perfectly predict whether market conditions in any particular period will be favorable for contracting.

Canadian Farmers' Decisions to Contract with U.S. Maltsters

A risk neutral representative prairie province farmer is assumed to plant a crop, either malt barley or a competing crop, on one acre of land. The farmer will plant malt barley if the returns (net of production and other costs) from contracting for delivery of the crop exceed the returns from raising the competing crop—spring wheat—on the land.⁶

⁶ While a variety of alternative crops are planted in the prairie provinces (e.g., canola, pulses, flax, oats, among others), spring wheat is a direct substitute in production with barley, as both are planted in the spring and the two grains account for a larger proportion of acreage than other wheat classes and alternative crops. In 2012, for example, the share of planted barley and wheat acres relative to total planted crop acres (excluding hay and summer fallow) was 46% in the Prairie provinces (Statistics Canada 2012). This implies that there is more than a sufficient amount of land currently allocated to spring wheat and other crops that could become available for malt barley production. The high elasticity of substitution therefore suggests that barley production

Effectively, the farmer seeks to maximize expected profits and will grow malt barley if the net returns from growing barley, π_b , are larger than the expected net returns from growing wheat, π_w . Let y_b and y_w represent expected per acre yields for barley and wheat, P_m the contract price of malt barley, P_f and P_w the expected cash prices of feed barley and wheat, b the cost of growing barley, c the cost of contracting, w the cost of growing wheat, and λ , the selection rate, lies between zero and one. Cost functions are increasing in expected yields and include both variable and fixed costs. The expected net returns or profits from producing malt barley and wheat are

$$\pi_b = y_b [\lambda P_m + (1 - \lambda) (P_f)] - [b(y_b) + c(y_b)] \quad (1)$$

$$\pi_w = y_w (P_w) - w(y_w) \quad (2)$$

The farmer is assumed to either contract to grow malt barley or sell spring wheat on the cash market. The selection rate affects the farmer's decision to contract for malt barley because malt barley contracts specify the criteria that must be satisfied for a crop to be accepted for malt. If the farmer's malt barley crop meets these specifications, then the farmer receives a premium price and the farmer's per acre revenue is $y_b P_m$. Otherwise, the farmer sells the barley for feed on the cash market and receives a per acre revenue of $y_b P_f$. Typically, $P_m > P_f$.

Under the reasonable assumption that per acre costs of growing malt barley are approximately equal to the costs of growing wheat (North Dakota Statistical Service 2012)—that is, $b(y_b) + c(y_b) = w(y_w)$ —the farmer will grow malt barley when⁷

$$\lambda P_m y_b + (1 - \lambda) P_f y_b \geq y_w P_w$$

This condition can be expressed as

$$\lambda P_m + (1 - \lambda) P_f \geq \frac{y_w P_w}{y_b} \quad (3)$$

U.S. Maltsters' Decisions to Contract with Canadian Farmers

Maltsters in the United States will source barley from Canada only if it is profitable for them to do so. Thus, the representative U.S. maltster seeks to minimize the cost of acquiring malt barley from farmers. The firm's cost of obtaining a unit of barley from any given farmer is

$$P_m + z(y_b) \quad (4)$$

decisions can easily adjust to meet the contracting requirements of both Canadian maltsters and U.S. maltsters, suggesting the same opportunity cost for farmers of contracting with either U.S. or Canadian companies. Increases in the Canadian companies' demand for barley are unlikely to have a major impact in altering the conditions necessary for contracting between Canadian farmers and U.S. maltsters.

⁷ For example, 2012 North Dakota crop budget estimates indicate that the sum of total costs for spring wheat is \$241.40 and the sum of total costs for malting barley is \$242.08.

where per unit contracting costs, z , may depend on barley yields in the region from which the barley is being sourced. For a U.S. maltster, prairie province barley contracting costs include transportation costs to U.S. facilities, costs due to Canadian variety registration requirements, and the price of the barley. A risk neutral U.S. maltster will contract with Canadian farmers if it is cheaper to purchase barley from Canada than from the United States. Thus, for a U.S. maltster to source barley from Canada, the following condition must be satisfied

$$P_m^{U.S.} + z^{U.S.} (y_b^{U.S.}) \geq P_m^{Can} + z^{Can} (y_b^{Can}) \quad (5)$$

where superscripts identify the country to which each variable applies.

Conditions for a Feasible Contract

Canadian farmers and U.S. maltsters will contract with each other for malt barley if the minimum malt price a Canadian farmer is willing to accept is less than or equal to the maximum price the U.S. maltster is willing to pay. Contracting occurs when

$$\frac{1}{\lambda} \left[\frac{y_w P_w}{y_b^{Can}} - (1 - \lambda) P_f \right] \leq P_m^{Can} \leq P_m^{U.S.} + z^{U.S.} (y_b^{U.S.}) - z^{Can} (y_b^{Can}) \quad (6)$$

Equation (6) indicates that contracting between U.S. maltsters and Canadian farmers depends on the expected selection rate, Canadian and U.S. wheat prices, wheat and malt barley yields, and the costs of contracting in the Canadian and U.S. markets. Comparative static effects of shocks to expected yields, prices, and selection rates in the Canadian and U.S. markets for wheat and barley are presented and discussed in the technical Appendix.

DATA DESCRIPTION AND THE SIMULATION MODEL

The provisions of the *Marketing Freedom for Grain Farmers Act* were implemented in August of 2012. As a result, currently, it is infeasible to directly measure the effects on contracting between U.S. maltsters and prairie province farmers for the production and delivery of malting barley resulting from the end of the CWB's single-desk authority. However, historical yield, price, and transaction cost information can be used in conjunction with the model presented above to simulate likely market conditions and provide insights about the distributional properties of contracting outcomes. Our analysis focuses on identifying incentives for such contracting in the prairie provinces of Alberta, Manitoba, and Saskatchewan and three U.S. states—Idaho, Montana, and North Dakota. These six regions produce most of the barley grown in each country, accounting for approximately 90% of total Canadian production and 70% of total U.S. production.

Barley and spring wheat yields and prices were obtained from the Canada Grains Council (CGCo; 2012) and the United States Department of Agriculture: National Agricultural Statistics Service (USDA NASS; 2012) for the periods 1964–2012 and 1974–2012, respectively.⁸ All Canadian yield data were converted from kilograms per hectare

⁸ Neither the Canadian nor the U.S. barley yield data differentiate between production sold for feed and production sold for malt. Therefore, only the average yields are available and used.

to bushels per acre using the CGCo's (2012) conversion factors: 36.744 bushels of wheat and 45.92 bushels of barley per metric ton. To estimate unbiased yield distributions using historical data, we need to account for technological advances over time. Following Goodwin and Mahul (2004), we first estimate barley and wheat yields in each state or province, j , as a linear function of time t , $y_{jt} = \beta_0 + \beta_1 t + e_{jt}$. Then, we determine the heteroskedasticity-adjusted "detrended" yield as $\tilde{y}_{ijt} = y_{ij,2012} \times (1 + \hat{e}_{ijt}/\hat{y}_{ijt})$, where \hat{e}_{ijt} and \hat{y}_{ijt} represent the predicted residual and yield values from the linear regression.

Monthly price information for U.S. spring wheat, feed barley, and malt barley were obtained from USDA NASS (2012). Malt barley prices were available for each month through September 2012 from April 1968 in North Dakota, April 1990 in Idaho, and April 1991 in Montana. Canadian price data were provided by the CGCo (2012) for 1965–2012. Under the CWB, farmers in all the prairie provinces received payments from pooled accounts, resulting in every farmer facing the same price within a particular marketing year.⁹ Different price pools represented the premiums and discounts that farmers received based on the grade of the delivered grain.¹⁰ For example, there were three pools of spring wheat prices (1 CWRS, 2 CWRS, and 3 CWRS) and after 2004, feed barley prices were divided into two pools (1 CW Feed Barley A and 1 CW Feed Barley B). We assume that a typical farmer is unable to precisely predict the overall quality of their grain and is likely to receive some weighted average across all price pools. Consequently, our Canadian spring wheat and barley prices represent an average value across all pools. Canadian prices are converted into U.S. dollars (USD) using the Bank of Canada noon spot market average exchange rate. These and U.S. market prices are then converted to 2012 constant dollars using the consumer price index provided by the United States Department of Labor: Bureau of Labor Statistics (2013).

Rail Distance and Transportation Cost Estimates

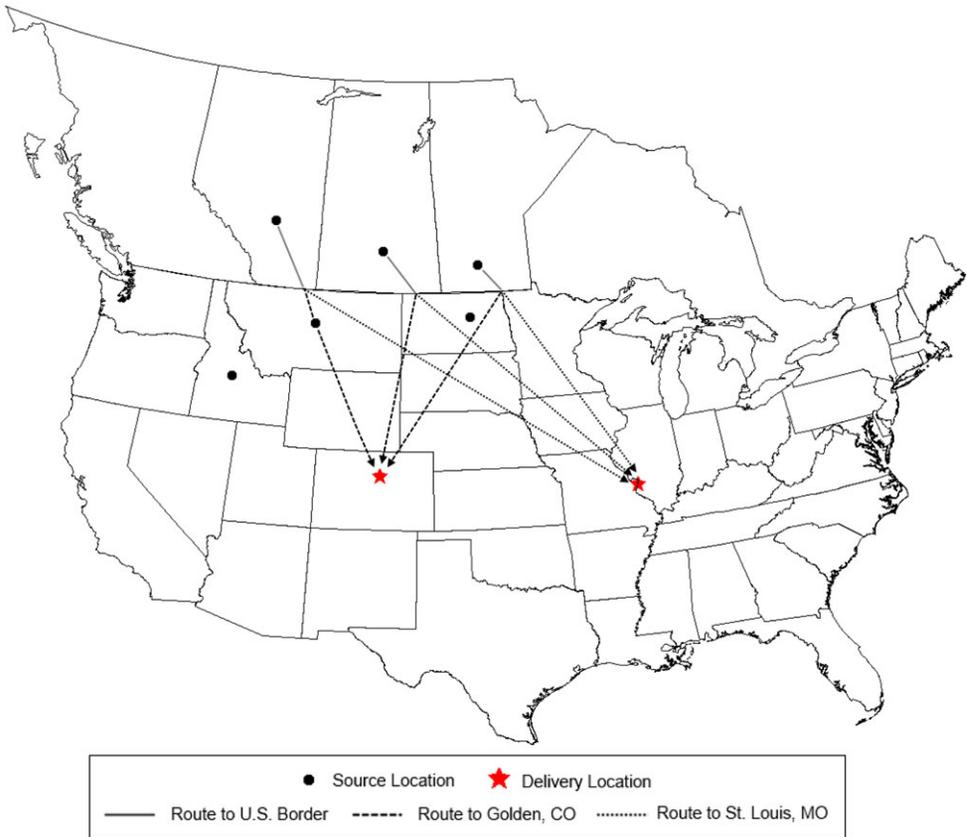
Transporting malt barley from U.S. and Canadian production regions is assumed to be an important variable cost for a U.S. malting firm. Figure 1 shows the Canadian and U.S. growing regions (marked by a filled circle) and the delivery destinations of U.S. brewing companies located in Golden, CO, and St. Louis, MO (marked by a star).¹¹ The approximate routes are represented by lines and are differentiated by the distance from the centroid of a Canadian growing region to major U.S.–Canada border rail hubs (solid line) and from the border to the final destination (dashed and dotted lines). Table 1 shows the total shipping distances and associated costs for delivering grain from Canadian and U.S. barley production regions to U.S. malting locations. Figure 1 shows that the proportional distance that grain must travel in Canada is substantially shorter than the proportion of total transportation that occurs in the United States.

A U.S. malting firm's total transportation costs are assumed to be a function of rail rates and total distance from each source location, which we assume to be the centroid

⁹ Some price differences did exist based on the location of local grain elevators to adjust for varying transaction costs. However, we were unable to obtain information about location-based price premiums and discounts.

¹⁰ Grain grades represented the quality of the product and were assigned based on the protein content and physical condition of the grain, such as frost damage or sprouted kernels.

¹¹ These are the primary locations and headquarters for MillerCoors and Anheuser-Busch.



Source: Figure constructed by the authors.

Figure 1. Malt barley shipment source and delivery locations and approximate rail shipping routes
 Notes: Grain source locations in each state and province are the average latitude and longitude of grain elevators using elevator location data obtained from BNSF, Union Pacific, and the CGCo (2012). Delivery locations are the MillerCoors plant located in Golden, CO, and the Anheuser-Busch plant located in St. Louis, MO.

of grain elevator locations in each state or province.¹² Historical Canadian rail rate data were collected from the CGCo (2012) for the marketing period 1975–2012 and represent the average rate to ship grain from Wilkie, Saskatchewan east to the St. Lawrence Ports on the Great Lakes or west to the Pacific Seaboard. The average of these rates for each marketing year was converted to 2012 USD per metric ton per mile using the same methodology described above to convert market prices. The United States Department

¹²Elevator locations were collected from the CGCo (2012) and the BNSF (<https://www.bnsf.com/customers/grain-facilities/elevators/>) and Union Pacific (<http://dx01.my.uprr.com/pubdir/graindir.nsf?OpenDatabase>) rail companies. Precise longitude and latitude coordinates for the centroids are available upon request.

Table 1. Total malt barley shipping distances and costs by origin and final destination

| | Canada | | United States | | Total | |
|------------------|---------------|------------|---------------|------------|---------------|------------|
| | Rail distance | Rail costs | Rail distance | Rail costs | Rail distance | Rail costs |
| To Golden, CO | | | | | | |
| Idaho | – | – | 917.978 | 0.056 | 917.978 | 51.580 |
| Montana | – | – | 810.112 | 0.056 | 810.112 | 45.519 |
| North Dakota | – | – | 925.843 | 0.056 | 925.843 | 52.022 |
| Alberta | 359.557 | 0.074 | 1,010.112 | 0.056 | 1,369.670 | 83.207 |
| Saskatchewan | 247.152 | 0.074 | 897.753 | 0.056 | 1,144.905 | 68.624 |
| Manitoba | 180.826 | 0.074 | 1,138.202 | 0.056 | 1,319.028 | 77.256 |
| To St. Louis, MO | | | | | | |
| Idaho | – | – | 1,792.135 | 0.056 | 1,792.135 | 100.698 |
| Montana | – | – | 1,664.045 | 0.056 | 1,664.045 | 93.500 |
| North Dakota | – | – | 1,080.899 | 0.056 | 1,080.899 | 60.734 |
| Alberta | 359.557 | 0.074 | 1,864.045 | 0.056 | 2,223.602 | 131.188 |
| Saskatchewan | 247.152 | 0.074 | 1,294.382 | 0.056 | 1,541.534 | 90.911 |
| Manitoba | 180.826 | 0.074 | 1,068.539 | 0.056 | 1,249.365 | 73.342 |

Notes: Grain source locations in each state and province are the average latitude and longitude of grain elevators using elevator location data obtained from BNSF, Union Pacific, and the CGCo (2012). Delivery locations are the MillerCoors plant located in Golden, CO, and the Anheuser-Busch plant located in St. Louis, MO. Estimated rail distances are in miles and costs are mean estimated rail costs in USD per metric ton per mile.

of Agriculture: Agricultural Marketing Services (2012) provided historical weekly U.S. rail rates in dollars per metric ton across different routes during June 2012–February 2013. Canadian rail rates are used for estimating transportation costs for shipping from a Canadian barley growing region to the U.S.–Canadian border, and U.S. rail rates represent marginal shipping costs from the border and from U.S. barley production regions to the U.S. malting firms.

Rail distances for these routes, which are not publicly available, were estimated using nearby road distances. Specifically, we first obtained actual rail distances across 260 location combinations using the Union Pacific online rail distance calculator. For the same location combinations, we used the Google Maps directions feature to determine road distances. Comparing these values to the actual rail distances, we found that, on average, road distances underestimated rail mileage by 11%. Thus, we estimated rail distances from the assumed origins and destinations by first obtaining the road distance for each route and multiplying it by a factor of 1.11.

Accounting for Price and Yield Dependence

Historical price, yield, and transportation cost data can be used to empirically characterize the distributional properties of each variable in a particular region. Then, draws from the specified distributions would represent possible production and market realizations, which can be used to identify when conditions are favorable for malt barley contracting. Following an extensive literature characterizing agricultural yield and price distributions

(e.g., Anibal 1989; Nelson and Preckel 1989; Smid 2004; Mitra and Boussard 2008), we test two sets of competing hypotheses for each yield and price variable distribution in each region. Specifically, we test whether historical yields in region j are more adequately characterized by a beta or normal distribution and whether historical spring wheat and barley prices and rail rates are more adequately characterized by a lognormal or normal distribution. To assess the robustness of each distributional assumption, we perform four different tests: Kolmogorov-Smirnov, Cramer-von Mises, Anderson-Darling, and chi-square.¹³

Table 2 presents a summary of distributional fit statistics for Canadian and U.S. price, yield, and transportation cost data. If the majority of the tests failed to reject the null hypothesis of a particular distribution, then that distribution was used. If both assumed distributions were not rejected or both were statistically rejected at a 10% level, then a beta distribution was assumed to characterize yields and a lognormal distribution to characterize prices. The results of the distribution tests indicate that all crop prices and transportation costs can be characterized by lognormal distributions, and yields can be characterized by a beta distribution in all but three locations (Idaho, North Dakota, and Manitoba).¹⁴ After determining each variable's density function, empirical distribution functions (EDFs) were used to estimate the parameters that provided the best fit to the observed historical data (for a description of distributional parameters, see Johnson et al 1994). Table 3 provides descriptive statistics of the estimated marginal distributions for each yield, price, and transportation cost variable and the estimated distributional parameters.

In addition to determining historical marginal distributions, it is also important to consider the potential for correlations among prices and yields within and across locations. Such correlations may occur because nearby regions are similarly affected by weather conditions (Xu et al 2010), large price differences are relatively quickly arbitrated away, and prices and yields are inversely related (Vedenov 2008). Correlation tests across yields and prices indicate the need to account for three types dependencies: within a location across barley and spring wheat yields and barley and spring wheat prices (i.e., $Corr[y_{b,i}, y_{w,i}] \neq 0$ for location i); between locations and across barley and spring wheat yields (i.e., $Corr[y_{b,i}, y_{w,j}] \neq 0$ for locations i and j); and between locations and across yields of a particular crop (i.e., $Corr[y_{b,i}, y_{b,j}] \neq 0$ and $Corr[y_{w,i}, y_{w,j}] \neq 0$ for locations i and j).¹⁵ Interestingly, there is no statistical evidence of dependence among spring wheat yields and prices and among barley yields and prices (i.e., we cannot reject that $Corr[y_b, p_b] = 0$ or $Corr[y_w, p_w] = 0$). Wheat yields and prices may be uncorrelated because wheat is a global commodity and changes in U.S. and Canadian production are not sufficiently large to have significant effects on world wheat prices. Chambers (2004), who also reports weak interdependence among barley prices and yields, argues that barley prices are more closely linked to corn prices because corn and barley are substitutes in animal feeds.

¹³Except the chi-square test, the distribution assessments are based on the EDF. See D'Agostino and Stephens (1986) for a rigorous discussion about EDFs and these distribution test procedures.

¹⁴In instances when a distribution could not be clearly identified, all analyses were replicated using both distributional options. The empirical results were qualitatively identical with trivial quantitative differences.

¹⁵Correlation test results are not reported for brevity but are available from the authors.

Table 2. Marginal distribution assumptions and *p*-values for yield, price, and transportation cost variables

| | Test for H ₀ : Normal distribution | | | | Test for H ₀ : Beta distribution | | | | Chosen distribution |
|----------------------------|---|-------|-------|-------|---|-------|-------|-------|---------------------|
| | K-S | C-vM | A-D | C-S | K-S | C-vM | A-D | C-S | |
| | Canadian yields | | | | | | | | |
| Alberta spring wheat | 0.150 | 0.250 | 0.187 | 0.097 | 0.500 | 0.500 | 0.500 | 0.529 | Beta |
| Manitoba spring wheat | 0.150 | 0.250 | 0.250 | 0.307 | 0.015 | 0.002 | 0.001 | 0.016 | Normal |
| Saskatchewan spring wheat | 0.150 | 0.250 | 0.154 | 0.001 | 0.250 | 0.250 | 0.178 | 0.030 | Beta |
| Alberta barley | 0.150 | 0.250 | 0.250 | 0.193 | 0.129 | 0.144 | 0.075 | 0.141 | Beta |
| Manitoba barley | 0.150 | 0.250 | 0.250 | 0.067 | 0.118 | 0.104 | 0.126 | 0.099 | Beta |
| Saskatchewan barley | 0.012 | 0.040 | 0.043 | 0.083 | 0.107 | 0.250 | 0.250 | 0.503 | Beta |
| U.S. prices | | | | | | | | | |
| Idaho malt barley | 0.010 | 0.005 | 0.005 | 0.001 | 0.150 | 0.113 | 0.049 | 0.084 | Lognormal |
| Montana malt barley | 0.010 | 0.005 | 0.005 | 0.001 | 0.150 | 0.449 | 0.260 | 0.001 | Lognormal |
| North Dakota malt barley | 0.010 | 0.005 | 0.005 | 0.001 | 0.010 | 0.005 | 0.005 | 0.001 | Lognormal |
| Cost to ship grain by rail | 0.010 | 0.005 | 0.005 | 0.001 | 0.010 | 0.005 | 0.005 | 0.001 | Lognormal |
| Canadian prices | | | | | | | | | |
| 1 CWRS | 0.010 | 0.005 | 0.005 | 0.001 | 0.089 | 0.049 | 0.068 | 0.372 | Lognormal |
| 2 CWRS | 0.012 | 0.005 | 0.005 | 0.001 | 0.022 | 0.033 | 0.032 | 0.053 | Lognormal |
| 3 CWRS | 0.012 | 0.005 | 0.005 | 0.001 | 0.150 | 0.060 | 0.087 | 0.643 | Lognormal |
| 1 CW feed barley | 0.029 | 0.006 | 0.005 | 0.003 | 0.150 | 0.136 | 0.141 | 0.840 | Lognormal |
| Cost to ship grain by rail | 0.127 | 0.049 | 0.041 | 0.182 | 0.150 | 0.500 | 0.500 | 0.258 | Lognormal |

Notes: K-S represents the Kolmogorov-Smirnov test, C-vM is the Cramer-von Mises test, A-D is the Anderson-Darling test, and C-S is the chi-square test. Distributional assumptions are tested using historical data from the CGCo (2012) and USDA NASS (2012), and then a marginal distribution for simulation is chosen if at least two of the four distributional tests fail to reject the null hypothesis. If the null hypothesis is rejected for both distributional assumptions, then the beta distribution is assumed for yields and the lognormal distribution is assumed for prices. 1 CWRS, 2 CWRS, 3 CWRS, and 1 CW feed barley represent price pools for Canadian spring wheat and barley, respectively.

Table 3. Marginal distributions and parameters for yield, price, and transportation cost variables

| | Distribution | Mean | Std. Dev. | Alpha | Beta |
|----------------------------|--------------|--------|-----------|-------|-------|
| U.S. yields | | | | | |
| Idaho barley | Normal | 93.137 | 13.106 | | |
| Montana barley | Beta | | | 2.428 | 1.710 |
| North Dakota barley | Normal | 64.807 | 14.560 | | |
| Canadian yields | | | | | |
| Alberta spring wheat | Beta | | | 2.244 | 1.059 |
| Manitoba spring wheat | Normal | 42.778 | 6.226 | | |
| Saskatchewan spring wheat | Beta | | | 2.131 | 0.935 |
| Alberta barley | Beta | | | 2.867 | 1.809 |
| Manitoba barley | Beta | | | 1.753 | 1.456 |
| Saskatchewan barley | Beta | | | 2.075 | 1.508 |
| U.S. prices | | | | | |
| Idaho malt barley | Lognormal | 4.583 | 0.900 | | |
| Montana malt barley | Lognormal | 4.458 | 0.854 | | |
| North Dakota malt barley | Lognormal | 5.336 | 2.493 | | |
| Cost to ship grain by rail | Lognormal | 0.053 | 0.023 | | |
| Canadian prices | | | | | |
| 1 CWRS | Lognormal | 8.937 | 4.397 | | |
| 2 CWRS | Lognormal | 8.655 | 4.276 | | |
| 3 CWRS | Lognormal | 8.228 | 4.157 | | |
| 1 CW feed barley | Lognormal | 5.169 | 2.562 | | |
| Cost to ship grain by rail | Lognormal | 0.073 | 0.013 | | |

Notes: All yields are in bushels per acre and all prices are in 2012 USD. 1 CWRS, 2 CWRS, 3 CWRS, and 1 CW feed barley represent price pools for Canadian spring wheat and barley, respectively. The costs to ship grain by rail are in USD per metric ton per mile.

We use a copula function to account for these relationships and simulate values from the joint multivariate distributions of yields and prices. Copulas provide a relatively simple and flexible approach to accommodate high-dimensional correlation structures among stochastic variables. Specifically, joint distributions can be characterized as the product of independent marginal probability densities and a unique copula function. For example, the joint yield distribution across locations can be characterized as:

$$f(y_1, y_2, \dots, y_j) = C(\theta; f_1(y_1), f_2(y_2), \dots, f_j(y_j)) \quad (7)$$

where $f(y_1, y_2, \dots, y_j)$ represents the joint distribution of yields across j locations, $f_j(y_j)$ is the marginal distribution of yields in location j , $C(\cdot)$ is the copula function, and θ is the copula function's dependence parameters, which characterize the dependence structure among the marginal density functions. By estimating empirical Spearman correlation structures among yields and among prices and using them to parameterize the copula function, we are able to simulate individual yield and price outcomes for each location while preserving historical rank correlations among those variables within and across locations.

SIMULATION RESULTS

Using a Gaussian copula function, we simulate 5,000 yield, price, and transportation cost values for each region, each of which represent draws from distributions about which malt barley contracting participants have *ex ante* expectations.¹⁶ These data are used to determine the lower and upper price bounds under which contracting in the deregulated North American malt barley markets is possible. The lower bound represents the price threshold below which a farmer would not be willing to accept a contract and the upper bound is the highest price at which a U.S. malting firm is willing to offer a contract. Specifically, we evaluate the condition

$$\frac{1}{\lambda} \left[\frac{\hat{y}_w \hat{P}_w}{\hat{y}_b^{Can}} - (1 - \lambda) \hat{P}_f \right] \leq P_m^{Can} \leq \hat{P}_b^{U.S.} \quad (8)$$

$$+ \left[\left(\hat{t}^{U.S.} \hat{d}^{U.S.} \right) - \left(\hat{t}^{Can} \hat{d}^{Can} + \hat{t}^{U.S.} \hat{d}^{U.S.} \right) \right]$$

where, for any price or yield variable, x , \hat{x} represents a simulated value; \hat{t}^k is the simulated rail rate in country k ; \hat{d}^k is the estimated rail mileage traveled in country k (and invariant across simulated draws); and all other variables are as described above.

For each set of simulated prices, yields, and transportation costs, we evaluate whether or not the upper bound exceeds the lower bound in Equation (8) to determine whether conditions are favorable for U.S. malting firms to contract with Canadian farmers. The evaluations are carried out for farmers in each prairie province relative to farmers in Idaho, Montana, or North Dakota. Contracting conditions are evaluated for selection rates ranging from 51% to 99%. Gustafson et al (2006) suggest that selection rates in the range of 51–65% are typical of dryland conditions, while selection rates between 80% and 95% are more typical for malt barley planted on irrigated land. Selection rates from 66% to 84% are assumed to represent atypically favorable dryland conditions. We restrict the simulated data to include only observations where the minimum farm price for malting barley is greater than the price of feed barley. The contract decision is based on farmers' and firms' expectations about future price and yield conditions, and it is unlikely that farmers will choose to establish a contract if they believe that feed barley prices will exceed malt barley prices.¹⁷

¹⁶See Trivedi and Zimmer (2007) for a description of the Gaussian copula. Using other copula specifications can more accurately represent the dependence structure in the tails of the joint distribution. However, our research focuses on understanding contracting decisions under typical market conditions rather than infrequent outcomes. A Gaussian copula function therefore is used primarily as a mechanism for preserving historical dependence structures rather than making strong distributional tail assumptions.

¹⁷The assumed distribution for feed barley prices resulted in the barley feed price exceeding the estimated minimum malt barley price in about 20% of the simulated market conditions. However, these values were generated from the tails of the estimated price distributions and, in fact, feed barley prices are observed to exceed malt barley prices much less frequently than that. The historical data indicate that in the United States, such price inversions have occurred once during the previous 30 years and did not occur in Canada. Therefore, because we wish to model normal market conditions, we discard these observations.

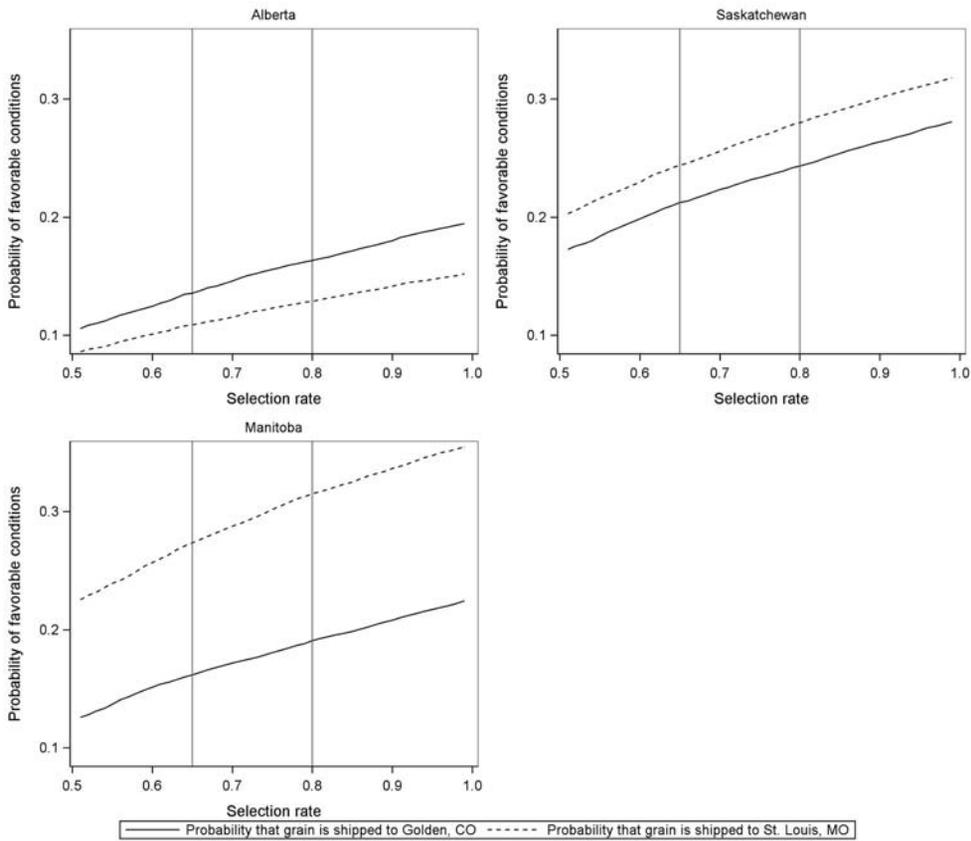
We carry out the following simulations. First, under the assumption that transportation cost, yield, and price distributions, and the correlation structures between those variables, are those estimated from historical data, we simulate the effects of allowing for contracting between Canadian farmers and U.S. maltsters. In the second set of simulations, we allow for potential changes in Canadian transportation costs. We then examine the impacts of relaxed varietal control policies on changes to spring wheat yield distributions.¹⁸

Contracting in the Absence of the CWB Single-Desk Authority

In the absence of a CWB single-desk grain marketing authority, we find that market conditions would sometimes be conducive for contracting between U.S. malting firms and prairie province farmers, but these conditions do not occur frequently. For each selection rate, conditions favorable for contracting between Canadian farmers and U.S. maltsters occur most frequently between the Missouri maltster and farmers in Manitoba. On average, such conditions occur in between 23% and 35% of the total simulations. Favorable conditions for contracting between the Colorado maltster and Manitoba farmers occur in only 13–22% of the total. For farmers in Saskatchewan, favorable conditions occurred in 20–32% of the simulations for contracting with the Missouri maltster and in 17–28 of the simulations for contracting with the Colorado maltster. Favorable conditions for contracting are observed least frequently for farmers in Alberta, occurring in only 9–19% of the simulations for contracting with either the Missouri or Colorado maltster.

Figure 2 shows the proportion of total simulations for which market conditions would make contracting feasible between farmers in each of the three prairie provinces and the two U.S. malting firms over the range of selection rates. As shown by the comparative static results presented in the Appendix, the frequency with which favorable conditions occur is positively correlated with selection rates. *Ceteris paribus*, the expected benefits from planting barley increase when there is an increase in the probability of producing a barley crop with characteristics that would make it suitable for malt. Figure 2 also shows that conditions favorable for contracting consistently occur more frequently for contracts between the Missouri maltster and Saskatchewan and Manitoba farmers. On average, conditions favorable for contracting with the Missouri maltster occur 3–12 percentage points more frequently than for contracting with the Colorado maltster. This result reflects the fact that relative to U.S. producers with whom the U.S. maltsters would otherwise contract, Missouri maltsters would have greater cost advantages to contract with Canadian farmers from these two provinces. The low frequency with which conditions favorable for contracting occur between either of the U.S. maltsters and farmers

¹⁸The assumptions about historical price and yield distributions are, to some extent, subject to the Lucas critique (Lucas 1976); that is, the historical yield distributions reflect a specific CWB single-desk policy environment, even though that market regime is no longer in place. While it is not feasible to estimate changes to the price distributions under the new policy (because of lack of data), the third set of simulations is an attempt to account for the potential effects on spring wheat yield in Canada.



Source: Figure constructed by the authors using simulated barley and spring wheat yields and prices and rail rates.

Notes: Conditions conducive to contracting occur when the contract price for producing and delivering malt barley from Canada rather than from the United States is greater than the lower bound on prices that Canadian farmers are willing to accept and less than the upper bound on prices that U.S. malting firms are willing to pay. The vertical line at the 0.65 selection rate denotes the expected upper bound for dryland production and vertical line at the 0.8 selection rate denotes the expected lower bound for irrigated production.

Figure 2. Probability of favorable contracting conditions by province

in Alberta suggests that transaction costs have a dominant role in the U.S. maltsters' contracting decisions.

Table 4 presents the average of the lower bound prices that occur when conditions are favorable for contracting over the range of selection rates. The results indicate that the average lower bound prices at which contracting occurs in Manitoba are higher than those in Saskatchewan and Alberta, and the lowest average lower bound prices are observed in Alberta. Table 4 also shows that the average upper bounds on the prices U.S. maltsters would offer farmers from each prairie province. The average upper bound price offered

Table 4. Malt barley lower and upper bound contract prices: Mean values and standard deviations by province and destination

| Origin | Destination | Farm price | | | | | | | | | | Firm price |
|--------------|---------------|--------------------------------|------------------|------------------|------------------|------------------|----------------------------------|------------------|------------------|------------------|--|------------|
| | | Dryland farming selection rate | | | | | Irrigated farming selection rate | | | | | |
| | | 0.51 | 0.55 | 0.60 | 0.65 | 0.80 | 0.85 | 0.90 | 0.95 | | | |
| Alberta | Golden, CO | 2.907 (1.143) | 2.956 (1.231) | 2.984 (1.253) | 3.007 (1.267) | 3.075 (1.326) | 3.096 (1.365) | 3.132 (1.433) | 3.147 (1.443) | 4.710 (1.862) | | |
| | St. Louis, MO | 2.777 (0.934) | 2.789 (0.957) | 2.825 (1.029) | 2.844 (1.053) | 2.893 (1.113) | 2.911 (1.131) | 2.924 (1.137) | 2.943 (1.205) | 4.456 (1.804) | | |
| Saskatchewan | Golden, CO | 3.273 (1.343) | 3.285 (1.357) | 3.311 (1.391) | 3.341 (1.459) | 3.369 (1.500) | 3.394 (1.536) | 3.406 (1.546) | 3.422 (1.553) | 5.053 (1.925) | | |
| | St. Louis, MO | 3.423 (1.233) | 3.436 (1.247) | 3.445 (1.265) | 3.482 (1.357) | 3.518 (1.398) | 3.531 (1.406) | 3.545 (1.428) | 3.555 (1.441) | 5.314 (1.848) | | |
| Manitoba | Golden, CO | 3.062 (1.249) | 3.092 (1.286) | 3.129 (1.331) | 3.159 (1.363) | 3.211 (1.452) | 3.223 (1.488) | 3.255 (1.529) | 3.268 (1.526) | 4.768 (1.892) | | |
| | St. Louis, MO | 3.558 (1.264) | 3.583 (1.312) | 3.597 (1.323) | 3.610 (1.338) | 3.651 (1.424) | 3.651 (1.436) | 3.659 (1.443) | 3.674 (1.455) | 5.554 (1.827) | | |

Notes: Farm prices are the means of the lowest prices Canadian farmers would be willing to accept when malt barley contracts are possible; that is, when farm price is less than the highest price, a U.S. maltster is willing to pay (firm price). Firm prices are malting firms' mean maximum willingness to pay. Contract prices are in USD per bushel.

by the Colorado maltster is lowest for farmers in Alberta, who are most distant from the plant, higher for farmers in Manitoba, and highest for farmers in Saskatchewan, who are closest to the plant. The average upper bound price offered by the Missouri maltster is also lowest for farmers in Alberta, who are most distant from that plant, higher for farmers in Saskatchewan, and highest for farmers in Manitoba, who are closest to the Missouri plant. These results indicate the importance of location and transportation costs in the contracting decision.¹⁹

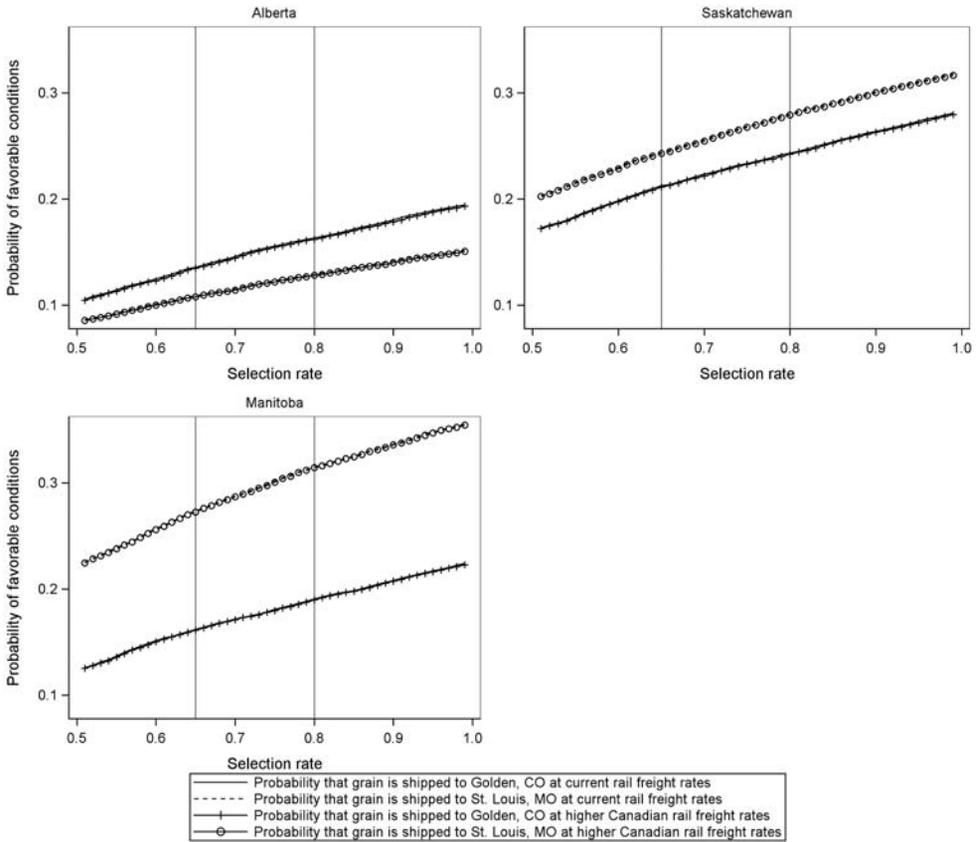
Contracting in a Deregulated Freight Rate Environment

The importance of transportation costs suggests that relaxing the revenue caps on Canadian grain rail transportation by the 1996 *Canadian Transportation Act* could have measurable effects on the likelihood of contracting. Following Vercammen (1999), we assume that in the absence of a CWB single-desk authority, grain transportation rates in Canada would be deregulated and increase by approximately 4% for shipments of barley to the U.S.–Canadian border. The cost of shipping barley from the U.S.–Canadian border to maltsters in Colorado or Missouri, however, would not be affected by changes in Canadian transportation policies. The change in Canadian freight rates only affects the upper bound prices in Equation (8) and we recalculate these prices to evaluate the effects increased Canadian freight rates on the frequency of contracting between U.S. maltsters and prairie province farmers.

Figure 3 presents the simulation results over the range of selection rates, showing the frequencies with which contracting occurs without the CWB single-desk authority but when the current cap on Canadian freight rates is imposed and when those freight rates increase by 4%. The deregulation of Canadian grain freight rates has only a trivial effect (less than a 1 percentage point reduction) on the frequency with which contracting would occur at every selection rate. As suggested in the Figure 1 map and by the shipping cost estimates reported in Table 1, the result reflects the fact that freight costs incurred in Canada only account for approximately 15% of the total delivery costs from the prairie provinces to the two U.S. maltsters. However, although the direct impacts of changes in Canadian grain transportation policies on shipping costs and the frequency with which contracting may occur are small, those changes could have indirect effects by altering the relative costs and returns to farmers associated with other commodities such as spring wheat.²⁰

¹⁹The simulation results can also be interpreted in the context of the extent to which economic rents may exist when market conditions are favorable for contracting between prairie province farmers and U.S. maltsters. For example, the minimum price at which an Alberta farmer is willing to contract with a Golden, CO, maltster is \$2.91 per bushel and the maximum price acceptable to the maltster is \$4.71. At the 2012 average Alberta barley yield of 60.3 bushels per acre, the total per acre rents available from contracting would be \$108.54 ($= (4.71 - 2.91) \times 60.3$). The distribution of these rents between the farmer and maltster depends on the bargaining power of each participant.

²⁰For example, the 1995 elimination of Canadian rail grain transport subsidies effectively increased the costs of grain transport and led to an increase in exports to the United States instead of offshore markets and an increase in grain production for domestic consumption (Doan 2003).



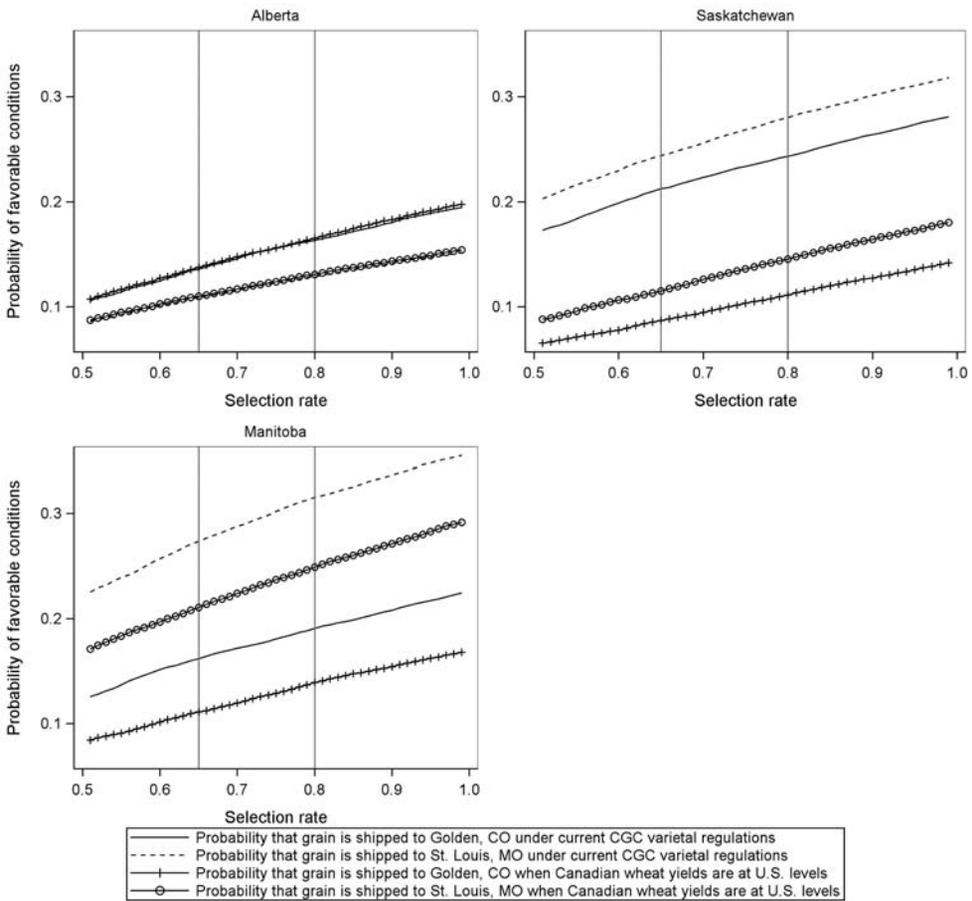
Source: Figure constructed by the authors using simulated barley and spring wheat yields and prices and rail rates.

Notes: Conditions conducive to contracting occur when the contract price for producing and delivering malt barley from Canada rather than from the United States is greater than the lower bound on prices that Canadian farmers are willing to accept and less than the upper bound on prices that U.S. malting firms are willing to pay. Removal of the Canadian grain rail transportation revenue cap is expected to increase the cost of shipping grain in Canada. The vertical line at the 0.65 selection rate denotes the expected upper bound for dryland production and vertical line at the 0.8 selection rate denotes the expected lower bound for irrigated production.

Figure 3. Probability of favorable contracting conditions by province in a deregulated freight rate environment

The Effects of Relaxing Varietal Control Policies for Spring Wheat

The likelihood that contracting for malt barley will occur between U.S. maltsters and Canadian farmers also depends on spring wheat yields, which affect the minimum price at which those farmers will contract for malt barley production. Spring wheat yields in the prairie provinces appear to have been adversely affected by the application of varietal controls such as those associated with KVD. For example, Ulrich et al (1987) suggest



Source: Figure constructed by the authors using simulated barley and spring wheat yields and prices and rail rates.

Notes: Conditions conducive to contracting occur when the contract price for producing and delivering malt barley from Canada rather than from the United States is greater than the lower bound on prices that Canadian farmers are willing to accept and less than the upper bound on prices that U.S. malting firms are willing to pay. The vertical line at the 0.65 selection rate denotes the expected upper bound for dryland production and vertical line at the 0.8 selection rate denotes the expected lower bound for irrigated production.

Figure 4. Probability of favorable contracting conditions by province after relaxing varietal control policies for spring wheat

that less strict varietal restrictions on spring wheat could increase Canadian farmers' opportunities to plant higher yielding spring wheat varieties with substantial effects on realized yields. Consequently, the data generation process described by the historical spring wheat yield distribution may change as a result of the new policy.

To simulate the effects of relaxing the CGC criteria applied for the release of spring wheat varieties, we respecify the parameters of the spring wheat marginal distributions for

Alberta, Manitoba, and Saskatchewan to reflect the distributional properties of average spring wheat yields across Idaho, Montana, and North Dakota. Padbury et al (2002) show that major spring wheat production areas in Canada and the United States share the same agroecosystems, suggesting that Canadian farmers' adoption of wheat varieties that are similar to those used in the United States would lead to comparable yield distributions across countries. The respecified spring wheat yield distributions demonstrate a 14% increase in expected Canadian wheat yields. Last, because brewers often specify that proprietary barley varieties must be planted, barley yields are assumed to be unaffected by changes in varietal regulation policies.²¹

Figure 4 shows the frequency with which contracting occurs over the entire range of selection rates under the assumption that CGC varietal controls remain restrictive and the frequency when those criteria for spring wheat are relaxed. The simulation results indicate that the frequency with which contracting occurs substantially decreases when varietal controls are deregulated and spring wheat yields increase. The likelihood that Manitoba farmers will contract for malt barley production and delivery with either the Missouri or Colorado maltsters falls by 3 percentage points. For Saskatchewan farmers, the likelihood that contracting will take place declines by 7 percentage points for the Missouri maltster and by 6 percentage points for the Colorado maltster. The initially low relative likelihood of contracting between Alberta farmers and either U.S. maltster declines by less than 1 percentage point.

These results indicate that compared to freight rate deregulation, access to higher yielding spring wheat varieties is likely to have a larger impact on malt barley contracting between Canadian farmers and U.S. maltsters. Moreover, while deregulated higher grain freight rates are likely to reduce the net returns to Canadian farmers (and their economic welfare) from both malt barley and spring wheat production, increased access to spring wheat varieties has a different effect. Contracting with U.S. brewers for malt barley becomes less likely because higher wheat yields would make the crop's production more profitable, increasing the opportunity costs of raising malt barley. The net effect would almost surely be an increase in economic welfare for western Canadian farmers who raise spring wheat and barley.

CONCLUSIONS

This study examines the incentives for contracting for malt barley between farmers in the prairie provinces and U.S. brewing companies in the absence of a CWB with single-desk authorities for malt barley. The research therefore falls firmly in the scope of the relevance and broader perspectives that Coase (1964) and Wolf (1979) called for from economic analyses. That is, we consider the possibility that moderating or removing regulation of a market by a government or quasi-government agency, such as the CWB's single-desk authority for marketing barley in the prairie provinces, may result in an improvement of economic welfare.

We develop a theoretical model of contracting decisions between western Canadian farmers and U.S. maltsters that accounts for market conditions, including crop prices, crop

²¹In fact, the marginal distribution parameters for historical Canadian barley yields are not statistically different from those for the U.S. production regions.

yields, uncertainty about crop quality (reflected in selection rates), and transactions costs. A simulation model based on the theoretical analysis is developed, which is calibrated using historical data on crop prices and yields in the Canadian Provinces of Alberta, Manitoba, and Saskatchewan and the U.S. states of Idaho, Montana, and North Dakota. Using Monte Carlo simulations in which draws are made from a copula function, the empirical model is used to estimate the frequency with which Canadian farmers and U.S. maltsters will have incentives to contract for malt barley.

Western Canadian farmers may face new opportunities for marketing grains in the absence of a CWB with single-desk marketing authority. However, the results of the simulation analysis indicate that market conditions suitable for contracting for malt barley production and delivery between western Canadian farmers and U.S. maltsters occur relatively infrequently. The likelihood that market conditions will be favorable to contracting ranges from 13% to 35% in Manitoba and from 17% to 32% in Saskatchewan, with higher frequencies associated with higher selection rates. The likelihood that contracting will occur in Alberta ranges from 9% to 19%, because farmers in Alberta are relatively far from the U.S. companies' delivery points compared to farmers in the major U.S. barley production regions of Idaho, Montana, and North Dakota.

The likelihood that contracting between western Canadian farmers and U.S. maltsters will take place also depends on other aspects of grain market regulation in Canada. If the revenue caps established by the 1996 *Canadian Transportation Act* were discontinued and rail costs for shipping Canadian grain were to rise by 4% (as estimated by Vercammen 1999), then Canadian malt barley contracting opportunities would not be significantly affected. This result reflects the fact that the rail costs of shipping barley to the U.S.–Canadian border constitute a relatively small proportion of the total cost of moving grain to the two U.S. maltsters. However, ending the transportation revenue cap could have substantial adverse impacts on farm gate prices for Canadian spring wheat exported through Vancouver or the Great Lakes by raising rail freight rates for spring wheat. These potential effects are not accounted for in this study but have been considered by others (see e.g., Fulton 2006).

Varietal release policies for spring and other wheat classes may also affect the likelihood that contracting for malt barley will occur between western Canadian farmers and U.S. maltsters. However, in the new institutional environment, a continued focus on restrictive criteria for the release of new varieties through the CGC's varietal approval process may constrain technology adoption by Canadian farmers, resulting in foregone revenue opportunities (Ulrich et al 1987). Modifying the varietal approval process to allow registration of higher yielding wheat varieties is likely to improve the returns to planting wheat, but would also increase the opportunity costs of planting malt barley and raise the minimum price at which a prairie province farmer would contract for the delivery of barley with brewers. The results of the simulation analysis indicate that these changes would substantially reduce the frequency with which contracting occurs in Manitoba (by an average of 5 percentage points) and Saskatchewan (by an average of 11 percentage points).

While the results of this study suggest that some potential exists for both Canadian farmers and U.S. brewers to benefit from increased direct contracting opportunities, changes to CWB's single-desk authority, grain transportation policies, and the varietal licensing program could have other effects. For example, prices received for domestic sales

by Canadian malt barley farmers may decline if those prices were sufficiently enhanced by the CWB's ability to mitigate adverse effects on malt barley prices resulting from the oligopsony structure in the North American brewing market. However, a comprehensive assessment of welfare effects associated with ending the single-desk authority requires modeling the resulting impacts on the exercise of market power given the current structure of the malting industry. In a dynamic context, it would also require an evaluation of potential changes associated with mergers and increased concentration in the Canadian and U.S. malting barley sectors. Both analyses would entail quantitative estimation of the impacts on malt barley planting, production, exports, and domestic consumption within a broader multimarket spatial modeling framework.

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APPENDIX: CONTRACTING CONDITIONS AND COMPARATIVE STATICS RESULTS

Equation (6), restated in this Appendix as Equation (A1), defines the conditions under which Canadian farmers and U.S. brewers contract for the production and delivery of malt barley; that is

$$\frac{1}{\lambda} \left[\frac{y_w P_w}{y_b^{Can}} - (1 - \lambda) P_f \right] \leq P_m^{Can} \leq P_m^{U.S.} + z^{U.S.} (y_b^{U.S.}) - z^{Can} (y_b^{Can}) \quad (A1)$$

Contracting occurs when the upper bound on the price a U.S. maltster is willing to pay Canadian farmers, $P_m^{U.S.} + z^{U.S.}(y_b^{U.S.}) - z^{Can}(y_b^{Can})$, exceeds the lower bound on the price the Canadian farmer is willing to accept, $\frac{1}{\lambda}[\frac{y_w P_w}{y_b^{Can}} - (1 - \lambda)P_f]$. The lower bound on the contract price is conditional on the selection rate, λ , Canadian wheat and barley yields, y_w and y_b , and Canadian wheat and feed barley prices, P_w and P_f . The upper bound depends on U.S. malt barley prices, $y_b^{U.S.}$, and Canadian and U.S. contracting costs, $z^{U.S.}$ and z^{Can} .

Let $P_{m,\min} = \frac{1}{\lambda}[\frac{P_w y_w}{y_b^{Can}} - (1 - \lambda)P_f]$ define the lower bound on the feasible contract price and $P_{m,\max} = P_m^{U.S.} + z^{U.S.}(y_b^{U.S.}) - z^{Can}(y_b^{Can})$ define its upper bound. The derivatives of the lower bound with respect to P_w , y_w , P_f , y_b^{Can} , and λ are as follows

$$\frac{\partial P_{m,\min}}{\partial P_w} = \frac{y_w}{\lambda y_b^{Can}} > 0 \quad (A2)$$

$$\frac{\partial P_{m,\min}}{\partial y_w} = \frac{P_w}{\lambda y_b^{Can}} > 0 \quad (A3)$$

$$\frac{\partial P_{m,\min}}{\partial P_f} = -\frac{1 - \lambda}{\lambda} < 0 \quad (A4)$$

$$\frac{\partial P_{m,\min}}{\partial y_b^{Can}} = -\frac{P_w}{\lambda (y_b^{Can})^2} < 0 \quad (\text{A5})$$

$$\frac{\partial P_{m,\min}}{\partial \lambda} = 1 - \frac{P_w y_w}{P_f y_b} \leq \text{or} \geq 0 \quad (\text{A6})$$

Increases in the price of wheat, P_w , and wheat yields, y_w , increase wheat revenues and the opportunity cost of growing malt barley, resulting in an increase in the minimum malt barley contract price a farmer is willing to accept. However, increases in the price of feed barley, P_f , and barley yields, y_b , increase expected barley revenues and decrease the minimum contract price. The sign of $\frac{\partial P_{m,\min}}{\partial \lambda}$ is ambiguous; however, under the most likely expected market condition that the expected revenue from selling wheat is greater than the expected revenue from barley sold on the feed market, $1 < \frac{P_w y_w}{P_f y_b}$, increases in the selection rate, λ , are expected to increase the likelihood of contracting; that is, $\frac{\partial P_{m,\min}}{\partial \lambda} < 0$. The derivatives of the upper bound contract price, $P_{m,\max}$, with respect to $P_m^{U.S.}$, $z^{U.S.}$, and z^{Can} are obvious and require no further discussion.