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Openness in Malting Barley Value Chains: The Case of Adoption of new Varieties in Canada and the United Kingdom

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ABSTRACT

Development of new malting barley varieties depends crucially on value chain acceptance. A case study analysis of the adoption of new varieties in malting barley value chains in Canada and the United Kingdom (UK) indicates that openness in value chains is a major contributing factor to a faster adoption rate for new varieties, even if firms conduct R&D in-house. Drawing upon the open innovation literature, this paper applies four degrees of openness framework across two dimensions: a firm's level of openness in innovation strategy, and its degree of openness with the rest of the industry.

Keywords: *open innovation; degrees of openness; value chain; malting barley; channel captains.*

1 Introduction

The global malting barley industry has been consistently growing in recent decades. However, the production of malting barley in Canada has been steadily decreasing by an average of 3% (JRP Consulting Group, 2015; Watts, 2016). In the Canadian malting barley industry, the same two barley varieties have dominated the market for the past twenty years. This varietal "lock-in" in agri-food value chains becomes a problem when there is a persistence of high sunk costs in R&D and a stagnation in varietal acceptance downstream. In contrast, in the UK the average lifespan of new malting barley varieties is five to ten years. The extent to which this marked difference in the rate of new varietal adoption stems from the interplay between firms' innovation strategies and their value chain relationships is examined in this paper.

ßThe malting barley value chain is highly dependent on downstream processing firms and provides an excellent example of co-dependency in the agri-food value chain where downstream firms drive the direction of innovation development. Maltsters and brewers determine the acceptance of a new barley variety, but the needs of the downstream firms do not always align with the needs of upstream firms. Farmers care about the agronomic characteristics of barley varieties (e.g., yield, insect and disease resistance), and a variety with poor agronomic performance will impact farmers' cropping decisions. On the other hand, breeders and seed distributing companies look for varieties with strong potential for further commercialization. Thus, the success of new varietal development depends on the alignment of the individual needs of barley value chain members with the common goals of the industry.

The purpose of this paper is to investigate the impact of the value chain members` chosen innovation strategy on the firm`s openness within the value chain with respect to information sharing and collaboration. It is still unclear whether firms that lean toward openness in their innovation development (i.e. drawing upon external resources and collaborations in the innovation process rather than relying primarily on in-house innovation) show similar openness in their relationships with the rest of the value chain. The framework in this paper builds upon previous research on open innovation and uses the concept of four degrees of openness in a value chain analysis. We explore innovation development strategy and openness in malting barley value chains as the primary drivers of successful innovation development. Drawing upon case study analyses we find that openness (i.e. information sharing and collaborations) within malting barley value chains contributes to a faster adoption rate of new malting barley varieties. Even if firms choose to conduct R&D in-house, the degree of openness with other members of the industry leads to an accelerated acceptance of new malting barley varieties.

This paper is structured as follows: Section 2 discusses the typology of open innovation and openness in value chains, explains the concept of captainship in agri-food value chains, and describes internal and external factors that can contribute to the degree of openness. Theoretical questions are developed in Section 3. Data and methods are discussed in Section 4. Case studies of malting barley value chains in Canada and the United Kingdom are described in Section 5 and discussed in Section 6; with, concluding remarks and limitations of the research provided in Section 7.

2 Literature and malting barley value chains

2.1 Openness in value chains

The agricultural "*supply chain"* or *"value chain"* is often described as the system that consists of various firms and organizations that co-depend on each other (Hobbs and Young, 2000; Leat and Revoredo-Giha, 2008; Leat et al., 2011; Gereffi and Fernandez-Stark, 2016). These firms and organizations may communicate and engage in business activities or never directly interact with each other. Nevertheless, they contribute to supply chain development, producing products and services that enhance innovation processes (Leat et al., 2011; Mena, Humphries and Choi, 2013; Stadtler, Kilger and Meyr, 2015; Gadde and Amani, 2016; Gereffi and Fernandez-Stark, 2016).

Innovation processes are often discussed together with the concept of openness in value chain development. The "*organization`s approach*" to openness applies to the firm`s innovation strategies or defines the relationships among value chain members (Martinez et al., 2014). A recent body of economic literature differentiates between closed and open innovation (OI) (Chesbrough, 2012). When a firm focuses on developing technologies "in-house", without reaching for knowledge outside of the firm, it utilizes a closed innovation approach (Barge-Gil, 2010; Chesbrough, 2012; Fu, 2012). An open innovation process exists when a firm draws upon external and diversified resources via collaboration and

cooperation when developing innovative technologies or processes (Gassmann and Enkel, 2004; Chesbrough, 2012; Garcia Martinez, 2013).

The OI concept has been popular in the context of high-intensive R&D industries (Bigliardi and Galati, 2013), but has received little attention in the agri-food sector (Bayona-Sáez et al. 2013). The lack of studies on open innovation in agri-food value chains is surprising because agriculture has a predisposition to openness through a large number of market-oriented (need-driven) supply chains, and a high dependency of agri-food industries on external sources of technologies and information (Acosta, Coronado and Ferrándiz, 2013; Bayona-Sáez et al., 2013; Wielens, 2013; Martinez et al., 2014).

In many instances, the demand-driven push to innovate starts from the so-called "channel captains". Micheels and Gow (2008, p.34) provide a useful description of the role of channel captains: *"…the majority of the information is gathered by the channel captain who owns the architectural knowledge. This firm or individual then shares or directs the other component participants with respect to input and output requirements, such as genetic selection or production practices to be followed."* (Micheels and Gow, 2008). This co-innovation often promotes openness among firms, lowers the level of competition, and affects the willingness of firms to be flexible instead of focusing solely on efficiency (Tepic et al., 2013).

One part of the literature claims that the larger the firms, the more natural it is for them to seek new knowledge and partnerships (Barge-Gil, 2010; Lazzarotti, Manzini and Pellegrini, 2011). Large companies have available resources and absorptive capacity to conduct open innovation strategies, and there is a direct link between R&D capacities and openness (Barge-Gil, 2010; Drechsler and Natter, 2012). Another part of the literature claims that small and medium-sized firms might also benefit from openness (Barge-Gil, 2010; Lazzarotti, Manzini and Pellegrini, 2011). The lack of internal R&D capacities drives small and medium-sized enterprises (SMEs) to search for external knowledge and seek collaborative partnerships. It has also been suggested that SMEs can reconfigure for knowledge exploitation faster (Mousavi and Bossink, 2018), while large firms may lack that degree of flexibility (Barge-Gil, 2010).

Firms operate in an external environment that also affects the degree of openness. Changing markets and environmental turbulence often make agri-food value chains innovate and seek external knowledge (Drechsler and Natter, 2012; Cruz-González et al., 2015). However, Drechsler and Natter (2012) point out that without systems of intellectual property (IP) protection, industries have a lower tendency to follow OI strategies. Firms often perceive that sharing too much can hurt their performance. Laursen and Salter (2014) suggest that formalization of collaborative partnerships improves openness and reduces a firm`s need to develop an additional protection mechanism.

2.2 Openness in malting barley value chains

Innovation development and the diffusion of new varieties in malting barley value chains pass through four primary value chain links: seed development, production, processing, and distribution (Fernandez-Stark, Bamber and Gereffi, 2011; Leat et al., 2011; Newton et al., 2011). The seed companies, grain traders, and malt traders can play either a supporting role or can be primary participants in the barley value chain. Public sector breeding programs often collaborate with private seed companies in further commercialization of new varieties. Grain growers produce a crop that they later sell to grain traders or directly to maltsters. Ideally, each primary and supporting value chain link consists of the two-way exchange of information that contributes to adoption of new varieties (see Figure 1).

Openness in the context of a malting barley value chain can both describe the information and resource exchanges among value chain members and define the innovation strategies that firms choose. Malting barley varietal development requires breeders to communicate closely with both grain producers (farmers) and downstream processing firms.

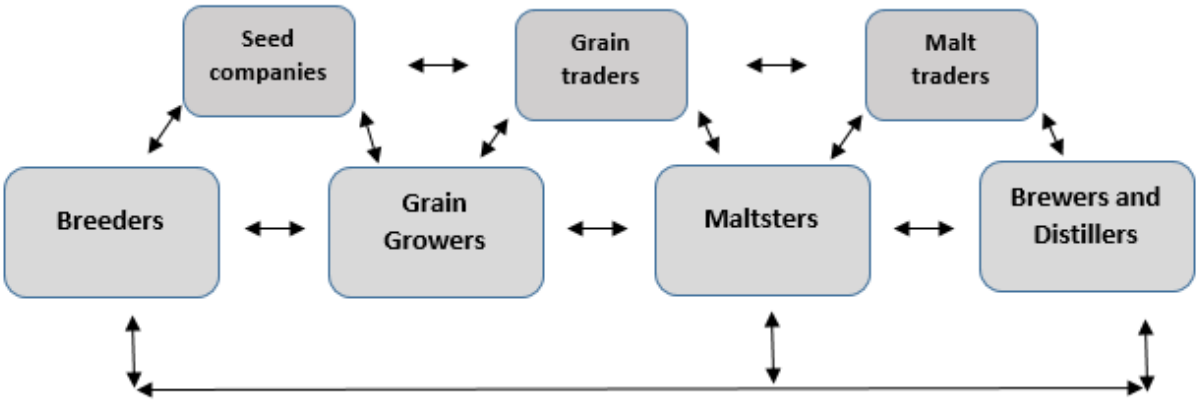

Figure 1. Two-way information flows in malting barley value chains

The brewers and distillers often determine the success of new barley varietal adoption. Without the acceptance of a new barley variety by the downstream firms, barley with malting and brewing qualities has lower value in other industries (e.g., feed industry). The livestock feeding industry can use malting barley in feed, however, the qualities of malting barley varieties do not always align with the preferences of the feed industry (e.g., malting varieties often have low protein).

3 Theoretical framework

While open innovation literature primarily focuses on internal factors, there seems to be a gap in understanding how external factors affect the degree of openness in innovation development. Agri-food industries typically operate in regulated environments with organizations that enforce food safety standards or monitor quality assurance (Hobbs, 2004; Swinnen and Kuijpers, 2008). In some economies, regulations and institutions ease the work of the industry; in others, they result in roadblocks and stagnation (Hobbs, 2012). Also, value chains vary in their level of vertical and horizontal integration. Consolidation and concentration have become a common characteristic of modern agriculture (Cakir and Nolan, 2015), but levels of concentration vary from one value chain to another. Hence, a firm`s regulatory and competitive environment influences its processes of innovation development.

In this paper, we suggest that openness in value chains is not always a result of choice. Internal factors, external forces, and previously formed relationships can impact the degree of openness in a value chain. Agricultural value chains consist of multiple actors, firms, and organizations that operate in the same socio-economic space. Geo-climatic characteristics of the specific region in which firms are located will affect how agri-food value chains operate, and what market regulations apply to the industry. These socio-economic factors have a direct impact on the direction of value chain development. Channel captains also determine the direction of development within agri-food value chains. This process can vary depending on how much and in what areas channel captains are involved in the value chain. Vertically integrated channel captains can choose different open innovation strategies. On the one hand, they can share information and collaborate outside of the firm`s organizational structures. On the other hand, they can limit their information sharing to members of their closed supply chains.

We know that knowledge sharing and some degree of collaborative interdependency in a value chain leads to a potential increase in overall openness in the value chain (Gadde and Amani, 2016; Öberg and Alexander, 2018). However, a high level of collaboration is often a result of effective intellectual property rights (IPR) mechanisms and well-coordinated systems of information transfer.

Sovacool et al. (2017) suggest that the degree of openness should be analyzed in the context of both the organizational structures of the firms and by the processes that open innovation often requires (e.g., coordination and control, knowledge sharing, market orientation). This framework implies that openness has different angles: the firm`s and the value-chain`s levels of openness. Firms may conduct R&D related to innovation development in-house, yet they may also be open to sharing information or partaking in collaborative work outside of their core activity. Firms that choose outsourcing may have a low degree of

openness with the other members of the value chain. Outsourcing only implies that a firm transfer some of the innovation activities and may have little reflection on the openness of the firm in the overall value chain.

To illustrate, public sector plant breeders tend to outsource commercialization of new crop varieties to private seed companies. The choice of outsourcing implies some degree of openness in the innovation process between breeders and seed companies. The decision to pursue an open innovation strategy is motivated by the internal limitations of public breeding programs, and by the choice of seed companies not to invest in their own R&D breeding capacities. At the same time, R&D on varietal development within public sector breeding programs often relies heavily on feedback from grain growers and processors, and results in a certain degree of openness between breeders and the downstream firms.

To analyze the degree of openness, we need to account for both the degree of openness in the firm`s innovation development activities and the degree of openness with the other links of the value chain (see Table 1). The evaluation framework was adapted from Sovacool et al. (2017) and Barge-Gil (2010).

Table 1.
Four types of firm`s openness

	The degree of openness in the firm`s innovation activity	**The degree of openness in the value chain**
Open	The firm`s innovation development is outsourced or involves a large number of collaborators.	Information is freely exchanged among value chain members.
Moderately Open	Some parts of the innovation development may be outsourced, but not all.	Information sharing is open to most parts of the value chain.
Moderately Closed	The innovation development of a firm is performed in-house.	Information sharing is limited to a few members of the value chain.
Closed	The firm`s innovation development is conducted in-house.	There is little necessity to share information with the rest of the value chain.

Centralized and decentralized organizational structures will have a different effect on the firm`s level of openness. On the one hand, vertically integrated organizations tend to have a unified channel of knowledge transfer that can facilitate innovation development processes. However, when there are too many business units to coordinate, it can also hinder the progress of innovation development. On the other hand, decentralized firms possess the advantage of being flexible to external changes in the industry, but they can have difficulty with coordination when there is a significant difference in social capital across agricultural value chains.

Different agricultural sectors vary in organizational structures. We observe a vertical integration tendency in many agri-food value chains in recent decades where large firms control some stages of innovation development upstream and downstream (e.g., grain cooperatives or private companies that participate in seed development, input distribution, grain trade and processing). Although, supply-chains like malting barley remain some of the more disintegrated value chain links.

The four degrees of openness can be represented as a two-dimensional sliding scale (see Figure 2). Firms that conduct innovation development in-house and prefer knowledge transfer within their supply chain are positioned in the left bottom corner in the *Closed* quadrant. Firms that involve other members of the value chain in innovation development and actively exchange knowledge are located in the upper right corner of the *Open* quadrant.

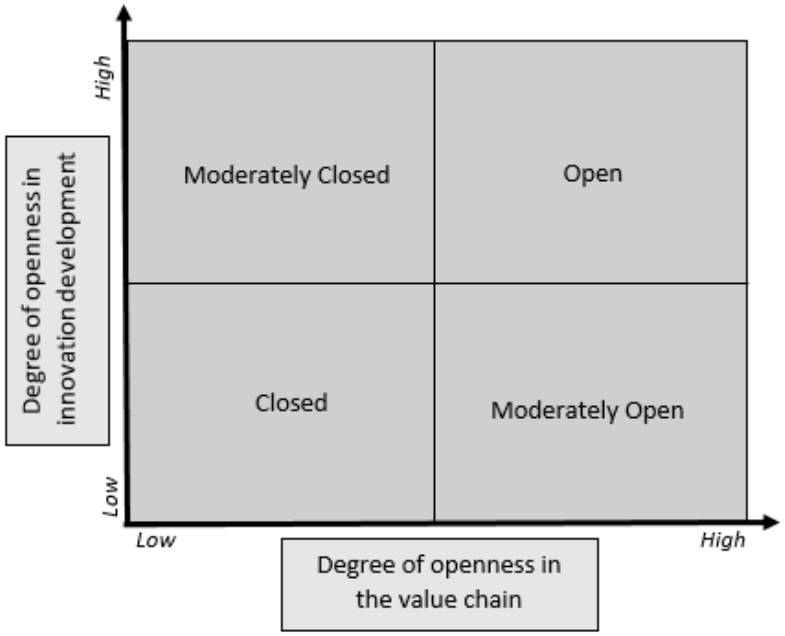

Figure 2. Four degrees of openness

However, it is somewhat unclear if openness in innovation development at the firm level leads to more openness in the value chain. Firms that conduct innovation development in-house can still be relatively open with the rest of the value chain, facilitating knowledge transfer. Firms that outsource innovation development can be relatively unconnected with the rest of the value chain in other respects.

4 Data and methods

The malting barley industry provides an excellent example of an agri-food value chain where the intersection of different basic quality requirements determines the success of innovation adoption and diffusion (Matzler and Hinterhuber 1998). First, there is a demand-pull from the downstream firms (e.g., maltsters and brewers) that expect certain malting and brewing characteristics from malting barley varieties. Second, grain growers expect stability in agronomic performance in crop production. Third, grain trading companies often have difficulty switching to new varieties if there is uncertainty in quantity and quality of crop production. Finally, breeding and seed companies invest in new varietal development only if new malting barley varieties have a likelihood of downstream commercialization. Every stage of the value chain can become both a bottleneck in the adoption yet can also contribute to the development of new malting barley varieties that fulfill the demands of the production and processing firms.

The theoretical framework on four degrees of openness developed in the previous section is used to examine the malting barley industries in Canada and the United Kingdom. These two countries differ markedly in the average length of time in which new barley varieties are adopted. The Canadian market remains dominated by two old varieties *AC Metcalfe* and *CDC Copeland* which were released in the late 1990s. In contrast, the average lifespan of new varieties in the UK is five to ten years. This dissimilarity in the rate of new varietal adoption could be attributed to firms' innovation strategies within the value chain, and this is the focus of the remainder of this paper.

The malting barley industries in both countries have a relatively small number of value chain members, and therefore a qualitative analytical approach was appropriate. Primary data was collected between February and May 2017, through semi-structured interviews with malting barley value chain members in North America and the UK. The Canadian industry sample consists of three out of the four largest malting companies that contribute approximately 90% of annual malt production in Canada; two of the largest beer producers that hold around 60% of the market share in Canada; the only private malting barley breeding company in Canada; the three main public sector breeding stations for new malting barley varieties; and two seed companies that are responsible for seed distribution in cooperation with public sector breeders.

In addition, interviews were held with producers` groups in Western Canada that represent grain growers in the provinces of Saskatchewan and Alberta[1].

The UK industry sample consists of malting companies that account for 75% of the UK market share; two beer producers whose combined market share is approximately 40% of the UK market; interviews with a non-for-profit industry organization representing the largest beer and whisky producers, maltsters, grain traders and private breeding companies; and public institutions that contribute to the malting barley industry in the UK (e.g., British Society of Plant Breeders). Overall, the sample for both the Canadian and UK cases includes a variety of different links in the malting barley value chain and is representative for further analysis. The complete list of 30 interviewed companies and organizations is provided in Appendix A and Appendix B.

The industry members were asked open-ended questions on new varietal development and diffusion in their value-chains, industry involvement, and the nature of communication and collaboration among organizations involved in the malting barley sector. Secondary data included web-resources, industry reports, and data provided by the malting barley industry members.

Initial contact was established through email and via attendance at industry events. Interviews were conducted either over Skype, in person, or over the phone. The duration of the interviews was between 30 to 60 minutes. They were recorded on the Smart Recorder Application on a smartphone and later transcribed for further analysis.

The semi-structured interview methodology has both benefits and weaknesses. On the one hand, it enables a more in-depth understanding of the processes in the industry. On the other hand, it increases the difficulty of the analysis and may lead to mistakes due to imperfect recollection by respondents and biases in the interpretation of data by researchers. However, the use of secondary data and recorded and transcribed interviews should minimize the errors and enhance the validity of findings (Sovacool et al., 2017).

Various stages of the value chain (from breeding to end-users) were analyzed with respect to the four degrees of openness using information from the semi-structured interviews along with the secondary data. For instance, each stage of the value-chain was assigned "*Closed*" or "*Moderately Closed*" if the innovation development processes were conducted in-house. The R&D processes in public institutions are relatively open by default in their value chain structures and were identified as "*Moderately Open*" in their internal innovation activity processes. In contrast, private breeding companies often conduct R&D in-house and were categorized as "*Moderately Closed*". If both private and public breeding institutions communicated and coordinated with the rest of the value chain, the breeders' value chain link was categorized as "*Open*" or "*Moderately Open*"

5 Case studies

In this section we present case studies of the malting barley industries in Canada and the United Kingdom. The four degrees of openness framework is subsequently used in Section 6 to examine the development and diffusion of new barley varieties within value chains.

5.1 A case study of the malt barley industry in Canada

Canada is the fourth largest producer of barley and second in global malt supply (CAFTA ACCA, 2016). The average annual production of barley in western Canada was estimated at 8.5 million tonnes from 2006 to 2016 (Canadian Grain Commission, 2016). On average, 2.2 million tonnes of barley is accepted for the production of malt, which is used both domestically and for export (Figure 3). Nevertheless, the last decade has shown a decline in barley production with an estimated average decrease of 3% per year since 1994 (JRP Consulting Group, 2015).

[1] Saskatchewan and Alberta produce over 90% of the malting barley in Canada.

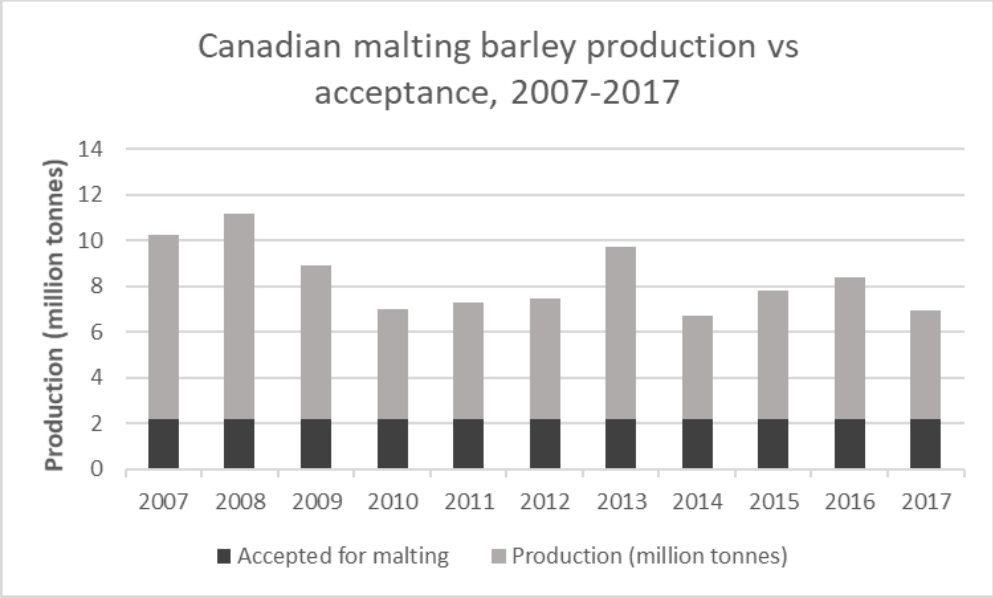

Figure 3. Canadian malting barley production vs. acceptance, 2007-2017. Source: Canadian Grain Commission (2017)

The decrease in barley production may be correlated with a noticeable trend towards higher-yielding crops, like canola or lentils that have improved agronomic characteristics and performed consistently well in the past years (JRP Consulting Group, 2015; Statistics Canada, 2017). Over the last 20 years, average canola, corn, and spring wheat yield characteristics have shown improvement by 30-50%, while barley has experienced approximately a 20% increase in yield (Statistics Canada, 2017).

The malting barley market in Canada has experienced varietal concentration, even though over thirty varieties were grown in recent years. Two-row varieties *AC Metcalfe* and C*DC Copeland* accounted for 76% of all malting barley grown in the 2016 crop year (CMBCT, 2016), and this trend has not changed significantly over the last ten years. Recent changes show a growing demand for *AAC Synergy*, which achieved an 11% growth in acre share in 2018, and according to interviews with supply chain members is predicted to reach 10-15% in the next year or two. The remainder of barley varieties accounts for less than 15% of total barley production in Canada (Canadian Grain Commission, 2018).

The long life of *AC Metcalfe* and *CDC Copeland* has been an increasing concern for the industry. Both varieties were registered at the end of the 1990s (*AC Metcalfe* in 1997 and *CDC Copeland* in 1999). Newly registered varieties often have higher yields and improved disease resistance characteristics in comparison with older varieties, yet the rate of adoption of many new varieties has been relatively slow.

5.1.1 Breeding and varietal registration

All barley R&D programs in Western Canada are conducted within public sector institutions, including Agriculture and Agri-Food Canada in Brandon, Manitoba (AAFC), the Field Crop Development Centre in Alberta (FCDC), and the Crop Development Centre at the University of Saskatchewan (CDC). Private sector funding for barley breeding that comes from the industry (e.g., SeCan, Viterra, Molson Coors, Anheuser-Busch, and Sapporo) contributes to public breeding programs. The availability of a solely public barley breeding industry in Canada indicates a high degree of concentration. Some breeding programs are overseen by private sector players, such as Molson Coors and ABInBev, but they are located in the U.S.. Similarly, Syngenta`s breeding facilities operate in other countries, but not in Canada.

To be released in Canada, barley varieties from other countries must go through the same pipeline of registration procedures (micro-scale trials) as any new barley variety developed in Canada (JRP Consulting Group, 2015). The macro-scale trials usually start after the variety has passed National registration, due to a limited amount of seed available. The interviews indicated that there is a limited seed distribution capacity in public sector breeding programs. Breeders must auction varieties to private seed companies that carry out multiplication and the distribution of seed to growers. An auction sale is only possible after registration at the National level, and not every variety that has undergone registration trials is chosen for further commercialization. Also, after a seed company for the variety is chosen, it is a common notion that public breeding institutions do not participate in further marketing of the variety in the supply chain.

Micro-scale trials	Variety Auction/Seed Multiplication	Macro-scale trials
Year 1-3	**Year 4-5**	**Year 6-7**
Breeders/Seed companies Grain companies (limited) Maltsters Brewers CMBTC/BMBRI	Breeders Seed companies	Seed companies Maltsters Brewers BMBRI

Figure 4. Timeline of varietal registration and testing in Canada[2]

If the seed company starts multiplication after registration at the National level, it takes several additional years for the industry to be able to run industrial trials of malting and brewing (see Figure 4). Thus, it may take five to six years in total for the new variety to pass all trials in Canada. For instance, the variety *AAC Synergy* was registered in 2012 by the CDC public breeding center. The private seed company Syngenta bought the rights for commercialization from CDC and the variety was available to growers in 2015. It was only after 2015 when maltsters and brewers had the opportunity to perform commercial scale trials with *AAC Synergy*.

5.1.2 Grain producers, grain handling and trade

Growers tend to work consistently with the same malting companies for years. Canadian growers and maltsters prefer to formalize their relationships via direct contracting. Maltsters prefer certified seeds because of varietal purity concerns, but it is usually not required in contracts. Maltsters typically allow usage of one-year farm-saved seeds for barley production.

Malting barley handling requires storage without mixing different varieties, and the grain germination rate should be over 95%. Grain handling of malting barley adds additional pressure and costs for grain handlers. Large grain trading companies in Canada (Richardson, Viterra, Cargill, and G3) operate a bulk-handling transportation system, and an accumulation of a large amount of seed for each malting variety is required. When there is not enough of a supply of the barley variety available, it is inevitable that grain traders prefer varieties that minimize costs and risks in handling.

Maltsters purchase a portion of malting barley from grain traders (which helps to diversify supply risk). However, the bulk handling system in Canada does not allow an easy switch between varieties after a new varietal introduction. Discussions with industry members suggest that grain traders tend to wait until domestic and international demand is established and enough grain is available before they switch to a new variety. It is also common for international customers to wait until the domestic market has accepted a new variety.

Grain trading companies are the primary information source for many international customers regarding available varieties. Discussions with industry stakeholders in Canada, however, suggest that grain companies do not participate actively in the promotion of new varieties. There are some exceptions, such as the cooperative work of Viterra with the Canadian Malting Barley Technical Centre (CMBTC) in international market development. Nevertheless, some level of reluctance is observed and acknowledged by industry members.

[2] Brewing and Malting Barley Research Institute (BMBRI) and Canadian Malting Barley Technical Centre (CMBTC) are not-for-profit organizations. Comprised of private and public sector stakeholders.

5.1.3 Maltsters

Canadian maltsters consume approximately 50% of the malting barley produced in Canada that meets malting specifications (CAFTA ACCA, 2016). The remaining 50% of Canadian malting barley goes for export. The biggest importers of malting barley from Canada are China (60%), the U.S. (31%), and Japan (7.3%). The EU and Australia are the largest barley producers and exporters in the world (CAFTA ACCA, 2016; Euromalt, 2016); they are the main competitors of Canada in China.

The malting industry in Canada consists of four companies: Canada Malting Co., Prairie Malt Ltd., Rahr Malting Canada Ltd., and Malteurop North America Inc. (Canada Malting Co. Limited, 2017; Cargill Ltd., 2017; Malteurop Group, 2017; Rahr Malting Co., 2017). Together they consume about 25% of the domestic malting barley supply. Approximately 65% of Canadian malt is exported (CAFTA ACCA, 2016). The largest importers of Canadian malt are the U.S., Japan, South Korea, and Mexico. The outlook for the malt competition is somewhat similar to malting barley exports, and Canada is competing with the top malt producing countries (e.g., EU member-states and Australia) (Watts, 2016).

In Canada, there is a limited degree of vertical integration between maltsters and the rest of the supply chain. Canada Malting owns nine grain elevators, and its parent company Grain Corp plans to expand its grain handling divisions in Canada within the next couple of years. Rahr has one grain elevator in the area of Fargo and Grand Forks in North Dakota, U.S., while Prairie Malt has access to Cargill and Viterra operations in Western Canada. In general, the interviews confirmed that the supply chain for malt in Canada is relatively independent, and downstream firms (e.g., maltsters and brewers) do not invest in breeding programs or own grain trading companies in Canada.

5.1.4 Brewers

The Canadian beer industry consumes 35% of Canadian malt production. Two leading companies represent large beer producers: Anheuser-Busch InBev (ABInBev) and Molson Coors with 26.8% and 31.7% market shares in Canada, respectively (Petrillo, 2017). ABInBev and Molson Coors in the U.S. have integrated supply chains between breeders, growers, maltsters, and brewers. In contrast, the Canadian malting and brewing industry works independently and has a low level of vertical integration.

Craft breweries have been on the rise in North America and consume a growing portion of domestically produced malt (i.e., around 30% of Canadian malt is consumed by Canadian craft breweries). Between 2010 and 2015, the number of licensed breweries doubled in Canada and is expected to keep growing (Watson, 2015). A discussion with the industry indicated that small brewers do not partake in the R&D and trial framework for new varieties.

5.1.5 Institutions

A significant part of international market development for malting barley was overseen by the Canadian Wheat Board (CWB) until 2012. After the removal of the single desk authority of the CWB in 2012, international market development responsibilities were taken over by different members of the supply chain.

Several not-for-profit organizations conduct market development and fund research that contributes to value chain development. The Canadian Malting Barley Technical Centre (CMBTC) is a small, non-profit research facility that contributes to research in malting barley and actively participates during varietal registration and trials. The Malting Industry Association of Canada (MIAC) represents four Canadian malting companies (Canada Malting, Rahr, Prairie Malt, and Malteurop). The Barley Council works with the whole barley supply chain, promoting barley usage domestically and internationally, and representing the industry to the Canadian government. Both organizations conduct domestic and international market development and actively contribute to discussions in international trade negotiations. The Brewing and Malting Barley Research Institute (BMBRI) represents both the malting and brewing industries in Canada. Finally, regionally-based producer groups such as SaskBarley, Alberta Barley, Manitoba Wheat and Barley Growers Association, and British Columbia Grain Producers Association also conduct market development activities in efforts to increase the global competitiveness of Canadian barley.

5.2 A case study of the malt barley industry in the United Kingdom

Over the last ten years, production of barley in the United Kingdom (UK) has been showing a positive trend in acres and production output (UK National Statistics, 2017). Malting barley varieties have a relatively quick turnover, although varieties that are suitable for both brewing and distilling tend to stay on the market longer.

Typically, the UK malting barley industry is separated into two regions - England and Scotland. Geographically they have different agronomic growing conditions and have had a distinct differentiation in industrial development: whisky and grain distilling production prevail in Scotland, and beer production is mainly located in England. Malting barley for brewing is mainly grown in England (UK National Statistics 2017), while Scotland produces most of the malting barley suitable for whisky and grain distilling. Malting barley in the UK is classified by the nitrogen content that reflects the protein content of the grain[3]. Typically, grain in the band below 1.65% nitrogen is demanded by malt distillers in whisky production. Barley with nitrogen content in the range of 1.65% to 1.85% is suitable for the brewing industry, and everything above it goes to grain distilling (MAGB, 2017). Based on data from 1991 to 2014, and confirmed in conversations with industry stakeholders, on average, it takes five to ten years for varieties to be replaced by new varieties.

5.2.1 Breeding and varietal registration

All barley breeding programs in the UK are private, and primarily owned by seed companies. Currently, the varieties of eight companies are listed in the AHDB Recommendation List (AHDB Cereals & Oilseeds, 2017). The breeding market can be described as highly competitive. The largest breeding programs belong to Limagrain, Agrii, RAGT, KWS, Syngenta, Secobra, and Saaten.

Micro-scale trials	Macro-scale trials
Year 1-2	**Year 3-5**
Breeders/Seed companies	Breeders/Seed companies
Grain companies/Cooperatives	Grain companies/Cooperatives
Maltsters	Maltsters
Brewers	Brewers/Distillers
Malting Association of Great Britain (MAGB)	Malting Association of Great Britain (MAGB)

Figure 5. Timeline for varietal registration and testing in the United Kingdom[4]

Breeders obtain Plant Breeder`s Rights (PBR) after passing the second year of National Registration trials, and this process is overseen by the British Society of Plant Breeders (BSPB). The UK system of royalty collection applies to both certified seed sales and farm-saved seed and follows the regulatory framework of the International Union for the Protection of New Varieties of Plants (UPOV91). For farm-saved seeds, farmers are legally required to claim how much farm-saved seed they have and pay 50% of the full royalty price on average (BSPB, 2017). Approximately half of the malting barley grown in the UK is from farm-saved seeds, and there is no specific requirement in contracts to use only certified seeds.

The varietal registration consists of the National level (NL) and Recommendation list (RL) trial frameworks. On average, it takes four to five years for a variety to undergo all tests. Macro-scale trials are conducted in the third year, and it is the responsibility of seed companies to provide enough sample material to maltsters (see Figure 5).

Conversations with industry members confirmed a high level of participation and involvement of breeders in the adoption process of new varieties – from the evaluation process to the promotion of the varieties directly to maltsters and brewers. At the malting barley evaluation stages, breeders are responsible for seed multiplication and provision of a sufficient amount for micro- and macro-scale trials. Also, interviews confirmed that seed companies try to maintain communication channels, whether with maltsters or brewers, to increase the chance of varietal acceptance by end-users.

In general, the information about new varieties in various stages of the NL and RL trials gets to maltsters and brewers through multiple information channels. Many seed companies have regular communication with grain companies, maltsters, and brewers in person, over the phone, or via email monthly.

[3]. The amount of nitrogen indicates crude protein content. To convert into protein indicators, multiply the nitrogen bands by 6.25 (MAGB, 2017)

[4] Malting Association of Great Britain (MAGB) is not-for-profit organization. Members include seed companies, grain traders, maltsters, brewers, and distillers.

5.2.3 Grain handling, cooperatives, and trade

There are many storage and grain trade options available to UK farmers because of a large number of cooperatives or grain traders that offer these services. Also, maltsters can work with multiple varieties at the same time because of the full range of storage capacities on their premises. Usually, maltsters prefer dealing with five to six varieties at most.

Quality control is conducted by organizations that oversee quality schemes for malting barley and malt production in the UK. For instance, the Assured UK Malt (AUKM) program is overseen by MAGB and is followed by four significant maltsters: Bairds Malt, Crisp Malt, Muntons, and Simpsons Malt. The quality scheme includes a regulatory framework for product quality and traceability and is used as a quality assurance for brewers and distillers.

The grain industry in the UK has a relatively high level of involvement by farmer-owned cooperatives – about 25% of the UK grain exporters trade malting barley. A large number of different producer cooperatives provide storage capabilities, input materials, and trade grain on behalf of the farmers. Some cooperatives also closely work with plant breeders. For instance, Openfield UK, a multipurpose cooperative, is involved in input supply, grain storage and marketing. The company cooperates with breeders in the preliminary stages of varietal development and has access to barley samples years before the variety enters the NL trials. Openfield also contracts to carry out seed multiplication for the NL and RL trials and has distributional rights for some of the malting barley varieties. The company provides inputs to farmers and conducts grain trade domestically and internationally. As a part of their communication strategy, they often conduct field trips, bringing brewers and maltsters to farmers' fields to facilitate an exchange of information and to build stronger connections within their supply chain (Openfield UK, 2017).

Similarly, one of the largest cooperatives, Fram Farmers Co-op, plays a significant role in barley trade in the UK and internationally. Fram Farmers Co-op provides farm and grain trading services to its members (e.g., seed, inputs, machinery, and crop insurance). Grain handling is done through a long-term partnership agreement with ADM (Archer Daniels Midland). ADM is also a shareholder, together with InVivo, of Gleadell Agriculture Ltd., another malting barley trade company that used to be a maltster in the 19th and 20th centuries. Relationships built over that time transferred into many partnership agreements for Gleadell with different breeders, maltsters, and brewers (Fram Farmers, 2017; Gleadell Agriculture Ltd, 2017).

Collaborative and cooperative agreements among supply chain members in the UK allow new varieties to be adopted relatively quickly. In the case of Openfield, because of the early access to new barley samples, they can regularly communicate to end-users about upcoming varieties, which allows maltsters and brewers to prepare for the varietal switch. When maltsters and brewers want to conduct additional internal trials before accepting the variety, it is relatively easy for Openfield and Fram Farmers to arrange grain supply through contracts with members of the cooperative. Similarly, grain trading companies, whether through long-term agreements with the maltsters or with parent companies, change to new varieties with relatively little resistance.

5.2.4 Maltsters

In 2016, the majority of UK malt was consumed by the distilling (49%) and brewing (32%) industries. The remaining malt was either exported (14%) or used in the domestic food industry (5%). Since the vast proportion of malt goes to the distilling industry, the varieties with lower levels of nitrogen (i.e., low protein) dominate the market. Typically, maltsters prefer working with multiple supply sources (e.g., grain traders, spot market transactions, and contracting directly with farmers) because it helps to minimize the risks of an unstable supply (MAGB, 2017).

The malting industry in the UK is dominated by six large maltsters and some relatively small maltsters. The largest are Boortmalt UK, Bairds Malt Ltd., Simpsons Malt Ltd., Crisp Malting Group Ltd., Muntons plc, and Soufflet Malt UK. The distilling and brewing industries play a significant role[5] in the overall economy of the United Kingdom. The Scottish whisky industry alone contributed over $5 billion to total UK exports (approximately 7% of total UK exports) in 2016 (UK National Statistics, 2017; Scotch Whisky Association Annual Review *2016-17*, 2017).

[5] According to the Scotch Whisky Association: "In value-added Scotch Whisky is bigger than the UK's iron/steel, textiles, shipbuilding, or computer industries; about half the size of the UK's pharmaceuticals or aerospace industries; and one third the size of the entire UK car industry." (*Scotch Whisky Association Annual Review 2016-17*, 2017)

5.25 Brewers

There are over 1800 registered breweries in the UK (Brewers of Europe, 2017), with a wide range of beer styles offered. The four largest beer producers are ABInBev, Molson Coors, Heineken, and Carlsberg[6]. Most of the large beer producers operate in multiple countries.

Imported malt to the UK comes from Ireland, Sweden, The Czech Republic, Belgium, and Germany. However, import volumes are not significantly large compared with domestic production and consumption, and less by half than the total malt exports from the UK worldwide (Statista, 2017b).

Exported malt from the UK goes to EU countries, North America, Latin America, Australia, Russia, and Middle Eastern countries. In general, the EU countries cumulatively export over 2 million tonnes of malt annually (Gray, 2015), and the share of UK malt in total EU exports is relatively small (Statista, 2017a).

Brewers, by nature, tend to be conservative and are reluctant to change their recipes. Considering that they have long-established reputations that depend highly on the flavor profile of their brands, it is no surprise that beer producers require additional time and additional trials to accept change. Discussions with industry stakeholders in the UK, however, suggest a strong understanding of the responsibility of the end-users to take into consideration barley growers when determining the future of new varieties so that agronomic characteristics are considered alongside good malting and brewing characteristics. An unstable supply of malting barley can impact end-users drastically, and they have a strong incentive to ensure that farmers are still interested in growing malting barley varieties instead of switching to other crops.

5.2.6 Institutions and communication

The members of The Maltsters' Association of Great Britain (MAGB) are major malting companies in the UK, in addition, different working parties within MAGB can consist of experts and representatives from the breeding industry (e.g., KWS, Limagrain, Syngenta), brewers (e.g., Molson, Heineken, Carlsberg), distilling companies (e.g., Diageo, Chivas), and different industry organizations.

Every year the MAGB publishes a forecast of the next year's purchases by nitrogen band in north England, south England, and Scotland to help farmers understand the expected market demand for the next crop year. The information is collated by MAGB from purchases provided by maltsters in previous years and is available on the MAGB website. The rejection rate of barley at the maltster`s delivery points is also published, and the average rejection rate was between 2.5 and 3% in the last ten years for all malting barley delivered (MAGB, 2017). It is worth noting that many deliveries to maltsters are not directly from farmers, but rather from grain traders or co-ops operating in the supply chain between farmers and maltsters.

Members of the MAGB meet twice a year. The purpose of meetings in the fall is to discuss varietal performance, seed availability and to confirm varieties for micro-scale and macro-scale trials. The main aim of the meetings in the spring is to discuss the results of trial data and decide which candidates move forward in the evaluation process. The varieties that have a significant improvement in yield, disease resistance, and show a high level of commercial potential are likely to be recommended. Many industry members indicated that agronomic improvements in new varieties have one of the most substantial impacts on the decision process.

6 Discussion

The case studies of the malting barley value chains in Canada and the United Kingdom provide an excellent example of the open innovation system. In Table 2 we provide points of difference that were identified as crucial in the adoption of new barley varieties.

[6] Reliable data on recent market shares (e.g., 2016/17) were difficult to obtain. Market shares across different years were as follows: Carlsberg 12% in 2016, ABInbev at 17.7% in 2015, Molson Coors with 18.8% in 2014, and Heineken with a 24% market share in 2013 (Carlsberg Group, 2016).

Table 2.
Points of difference in the malting barley value chains in Canada and the UK

Canada	The United Kingdom
Breeders and Seed companies	
Public breeders must auction varieties to private seed companies for further grain marketing and distribution.	Private seed companies conduct both breeding and grain marketing.
Farmers	
Farmers sell malting barley through a direct contract to maltsters.	There is a higher presence of cooperatives in the value chain. Farmers sell to grain traders instead of direct contracting with maltsters.
Grain traders	
Small involvement in the organizational processes of new varietal trials. The grain sellers usually wait for the international and domestic markets to establish before accepting new varieties.	Grain traders play an active role in the micro and macro-scale trials through The Maltsters' Association of Great Britain (MAGB). Often cooperatives perform grain marketing and distribution functions.
Maltsters	
Malting barley industry shows a high level of concentration.	The malting industry indicates a lower level of concentration.
End-users (brewers, distillers, and whisky producers)	
Downstream firms conduct macro-scale trials after varietal evaluation and conditional on the seed availability.	End-users are able to conduct macro-scale trials of new varieties in Year 3 of the evaluation tests.

The malting barley industry in Canada represents an example of a value chain with little vertical integration and relatively loose coordination. Coordination among members of the value chain heavily relies on not-for-profit regional producers' groups and industry organizations. From the interviews and analysis, we can observe many moderately closed members in the value chain (see Table 3). In particular, the grain trading industry operates independently from the rest of the malting barley industry. The costs of handling barley versus other commodity crops like canola or wheat can contribute to the low degree of involvement of grain traders in a quick varietal diffusion. The interviews confirmed that some reluctance in the adoption of new varieties by grain companies exists if there is uncertainty over acceptance by international and domestic customers.

One of the notable characteristics of the Canadian value chain is the *Moderate Openness* of breeders. Public breeding has limited capacities to partake in further commercialization of new varieties and outsourcing to seed companies has become a widespread practice. A transfer of seed production to seed companies leads to openness in the innovation activity of breeders but results in a slower adoption rate.

In Canada, end-user trials for the National registration of varieties are conducted by the Brewing and Malting Barley Research Institute (BMBRI), and the Recommendation List trials and the publication of results are overseen by the Canadian Malting Barley Technical Centre (CMBTC). A lack of confirmation from end-users about new varieties results in increased uncertainty for growers regarding which varieties to grow. Furthermore, the lack of available seeds for commercial macro-scale trials increases uncertainty and creates a resistance to change among downstream firms.

The fact that breeders are not responsible for macro-scale trials contributes to a prolongation of the period between development of new varieties and when the downstream firms can have access to grain for testing. There is one exception – a private seed company Syngenta conducts R&D on breeding in different countries and has a relatively closed information channel with the end-users of the industry (e.g., openness within their value chain, but moderately closed to other members of the industry). This direct contact with downstream firms lets Syngenta organize macro-scale trials sooner.

Table 3.
Degrees of openness in the Canadian malting barley value chain

	The degree of openness in innovation development	*The degree of openness in the value chain*
Breeders	Moderately Open	Open
Seed companies	Moderately Closed	Moderately Open
Grain growers	Moderately Closed	Moderately Open
Grain traders	Closed	Moderately Closed
Maltsters	Moderately Closed	Moderately Open
Brewers	Moderately Closed	Moderately Closed

The Canadian malting and brewing industries are characterized by being *Moderately Closed* with respect to their internal innovation processes. The communication between brewers and maltsters is closed from the rest of the value chain members, which may lead to a reduction in the information exchanged with other members of the value chain. The downstream firms in the Canadian malting barley value chain seem to play the role of channel captains – there is a strong relationship between acceptance of new varieties by maltsters and brewers and varietal adoption rate. The contractual form of grain sales to malting companies results in a power shift where maltsters buy what brewers demand, leaving farmers bound to the varieties specified in a contract.

In contrast, it appears that the value chain in the UK has a relatively high degree of coordination and openness, which is partially a result of the supply chain structure (e.g., cooperatives or the establishment of long-term supply chain partnerships). Vertically integrated cooperatives enable a faster process of varietal registration and acceptance by farmers, grain traders and downstream firms. The interviews with industry stakeholders indicated that breeders, grain traders, maltsters, and malt end-users take an active part in the organizational process of varietal evaluation, and the promotion of new varieties. Even though seed companies in the UK conduct breeding and seed production mainly in-house (*Closed*), the degree of openness to the rest of the value chain can be characterized as *Moderately Open* (see Table 4). Breeders have a direct communication channel with grain companies, maltsters, and brewers, which facilitates up-to-date two-way information exchange.

The stronger presence of cooperatives in the malting barley value chain in the UK has a positive effect on the adoption rate of new varieties. Cooperatives like Openfield are involved in the organization of trials because of their function as grain distributors and grain growers. In the UK malting barley industry, channel captainship is split between a larger number of firms involved. We can observe, like in the Canadian case, that the downstream firms drive the direction of varietal acceptance, yet the grain farmers and grain traders in the UK share some of that decision-making power.

Table 4.
Degrees of openness in the malting barley value chain in the United Kingdom

	The degree of openness in the innovation development	*The degree of openness in the value chain*
Breeders	Moderately Closed	Moderately Open
Seed companies	Closed	Moderately Open
Grain growers	Moderately Closed	Moderately Open
Grain traders	Moderately Open	Moderately Open
Maltsters	Moderately Open	Moderately Open
Brewers and distillers	Moderately Open	Moderately Open

The link between maltster and brewer plays one of the most significant roles in varietal adoption. The Malting Association of Great Britain (MAGB) takes responsibility to arrange macro-scale trials with brewing participants and passes the information on new varieties to maltsters, brewers, and the rest of the UK industry members. This openness of the channel captains in the core activity and the overall value chain seems to have a substantial impact on the success of new varietal adoption. The participation of

end-users in the Recommendation List trials sends a strong message to other members (e.g., grain growers and grain traders) in the malting barley supply chain about the acceptability of new varieties.

The UK case study provides an example of vertical integration of various parts of the value chain, contributing positively to the overall openness of the malting barley industry. This openness is achieved through direct communication channels between upstream and downstream firms, early macro-scale trials of new varieties, and coordinated efforts through the value chain.

6 Conclusions

Agri-food value chain development is highly dependent on innovation adoption. Firms can choose from two types of innovation strategies – open and closed. Different contractual and behavioral relationships occur at each stage of the supply chain, and the direction of the effect (upstream or downstream) is often determined by the "channel captains" of the industry. The attributes of the markets and firms, and where those value chains operate, are also believed to have a substantial impact on the degree of openness in agri-food value chains.

This paper contributes to the discussion on open innovation and the concept of openness in agri-food value chains. The analysis of the OI processes include two levels of openness – the firm's level of openness in innovation development and the degree of openness with the rest of the value chain. The argument is that internal factors motivate a firm`s decision regarding openness in innovation development. However, the openness of the firm needs to account for the degree of openness to the rest of the value chain. An analytical framework evaluating the degree of openness was applied to two case studies of the malting barley sectors in Canada and the United Kingdom. The case study analysis indicates that more open barley value chains facilitate faster adoption of new barley varieties. A higher degree of openness was observed in the UK malting barley value chain and is believed to be the main reason for the faster adoption rate of new malting barley varieties relative to what is observed in Canada. Multiple opportunities for information exchange, well-coordinated arrangements of trials, and a high level of involvement of all industry players in developing and implementing mutually aligned industry development goals contribute to effective innovation adoption in UK barley value chains.

On the other hand, the Canadian case exemplifies how the lack of openness among all members of the value chain can negatively impact innovation adoption. Bottlenecks in the adoption of new malting barley varieties were noted between upstream and downstream firms. First, the reluctance of the grain trading companies to adopt new varieties impacts market development. Second, the late access to grain for macro-scale trials in malting and brewing results in a low level of interest among channel captains in accepting new varieties. The non-integrated value chain structure of Canadian barley value chains may have an impact on the openness along the value chain. The lower level of vertical integration contributes to higher coordination and communication costs and reduces the degree of openness. However, the supply chain structure cannot solely affect the degree of openness. Information exchange can be facilitated in non-integrated value chains, and thus, to explain the low degree of openness, we need to consider the economic and institutional environment.

The case study approach used in the paper has limitations, namely it provides an in-depth understanding of key processes but reduces the dynamics of the analysis to a single snapshot of the barley market in each value chain. Nevertheless, the analysis allows insights from a multidimensional perspective across the value chain.

This paper adds to the body of literature on innovation in agri-food value chains by developing an analytical framework on four degrees of openness and demonstrating the applicability of the framework using the case of malting barley value chains in Canada and the United Kingdom. Further research would add to the discussion and understanding of the role of openness in innovation adoption in agriculture. The addition of longitudinal studies to capture dynamics in value chains could enhance the analysis of the research topic. Future research could also investigate the effects of R&D and IP regulatory frameworks on the degree of openness. Further examination of captainship in both upstream and downstream stages of the supply chains and its impact on the degree of openness could be advantageous. The extension of the analysis to different agri-food value chains and other countries may provide different insights.

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Appendix A — List of interview participants in Canada

#	Title	Description
1	Canadian Malting Barley Technical Centre (CMBTC)	Non-profit organization and research center
2	Paddockwood Brewery	Craft brewer
3	Canada Malting	Maltster
4	Anheuser-Busch InBev (ABInBev) North America– 2 interviews	Beer producer
5	Molson Coors North America- 2 interviews	Beer producer
6	Syngenta	Private seed company
7	Brewing and Malting Barley Research Institute (BMBRI)	Industry organization (maltsters, brewers)
8	Rahr Malting	Maltster
9	Prairie Malt (Cargill)	Maltster
10	Field Crop Development Centre, Lacombe (FCDC)	Public breeding program
11	Crop Development Centre University of Saskatchewan (CDC UofS)	Public breeding program
12	GrainCorp	Grain trader
13	Agriculture and Agri-Food Canada, Brandon (AAFC, Brandon)	Public breeding program
14	BarleyCouncil/Malting Industry Association of Canada (MIAC)	Non-profit/Industry organizations
15	Viterra	Grain trader
16	SaskBarley Development Commission	Non-for-profit organization (Grain growers)
17	Alberta Barley	Non-for-profit organization (Grain growers)

Appendix B — List of interview participants in The United Kingdom and EU

#	Title	Description
1	The National Institute of Agricultural Botany (NIAB)	Research non-profit organization
2	Soufflet UK	Maltster
3	British Society of Plant Breeders (BSPB)	Industry organization (breeders)
4	Malting Association of Great Britain (MAGB)	Non-profit/Industry organization (malting, brewing, and distilling)
5	Openfield UK – 2 interviews	Seed company/Cooperative
6	Muntons Malting	Maltster
7	Crisp Malting	Maltster
8	Molson UK	Beer producer
9	Boortmalt UK	Maltster
10	Bairds Malt UK	Maltster
11	The Scotch Whisky Research Institute (SWRI)	Research organization
12	Anheuser-Busch InBev (ABInBev) EU	Beer producer
13	Syngenta EU	Private breeding/Seed company