Case study

Managing the value of new-trait varieties in the canola supply chain in Canada

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Keywords

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Abstract

Identifies the drivers, classifies the structures, examines the governance systems and estimates the relative economic costs and benefits of various identity-preserved production and marketing (IPPM) systems that have evolved in the Canadian canola industry. The systems vary significantly, depending on whether they are managing input- or output-based, traditionally bred or biotechnology-based traits. Combines transaction costs and principal-agent theory in a synthesized transaction cost-agency model that allows for predictions regarding the organizational form of vertical integration based on the degree of asset specificity, task programmability and non-separability. Transactions for new, proprietary, novel-trait canola varieties require a more extensive set of institutions than traditional varieties. Identity-preserved production and marketing systems appear technically feasible for smaller units of production, but it is unclear whether they are economically viable for long-term or larger-scale operations. IPPM systems can provide an effective and proven method of controlling risks and liabilities.

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Introduction

Agriculture is going through a fundamental transformation from a loosely connected array of related markets into a set of increasingly vertically managed supply chains. Technology (e.g. advanced breeding and biotechnology) is making it possible to "engineer" new differentiable traits in crops and animals, while, at the same time, it offers new possibilities to test for and detect value-enhancing or value-reducing traits. Meanwhile, consumers and, by extension, processors are becoming more demanding about the quality and provenance of their food. As a result, the global agri-food sector is investing heavily in new supply chain structures to match those converging supply and demand trends.

The Canadian canola sector offers one example of the challenges and approaches in undertaking this transformation (Phillips and Khachatourians, 2001). Over the past 30 years, the canola industry in Canada, has begun to specialize, with an increasing percentage of the varieties and acreage grown under managed production and marketing arrangements. Up to and including the 2001 crop year, 110 of the estimated 275 varieties registered for production in Canada exhibited some trait that either required or encouraged identity-preservation efforts and 77 of the 110 varieties were developed using transgenic methods. The production and marketing arrangements vary substantially, depending on the regulatory requirements and the market prospects for the products.

This paper surveys the array of new varieties being licensed and identifies and examines five separate supply chains which have evolved. Section two discusses the scope and array of varieties that have already been released and looks at the field trial data to anticipate the potential for new varieties. Section three provides a conceptual framework for examining developments in this area. Section four compares and contrasts the five identifiable production and marketing systems. Section five examines some the implications of this analysis for the future and for other products and markets.

Background and circumstances

The extension of modern biotechnological techniques (e.g. genomics, marker-assisted breeding, micropropagation, cell tissue culture and transgenics) into the crop breeding industry has both accelerated new variety development and acted to encourage private investment in new differentiated product attributes. This has been

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visible on two levels. Many breeders have adopted the techniques to develop new varieties that simply enhance the existing genetic base of crops, which has both shortened the breeding process and enhanced the targeting of effort. A wide variety of new, non-transgenic crops has flowed from this effort. Meanwhile, significant effort has been directed to developing new transgenic varieties with commercially attractive input or output traits.

A range of agricultural products has been and is presently produced and marketed using identity-preserved production and marketing (IPPM) systems. A number of recent studies have examined their structure and function. Smyth and Phillips (2001) examined the IPPM system used for genetically modified, herbicide-tolerant canola in Canada in the mid-1990s. Bender *et al.* (1999) looked at several IPPM systems for corn in the USA. Bender and Hill (2000) and Good *et al.* (2000) investigated the IPPM systems used for speciality varieties of soybeans in the USA; Maltsbarger and Kalaitzandonakes (2000) examined the US corn system; Lin (2002) looked at non-GM corn and soybeans in the USA; and Kennett (1997) and Smyth and Phillips (2002a) analysed the special IPPM system for high-protein wheat for export to the UK.

During the 1990s, the canola industry had to manage the introduction, production and marketing of more than 275 new varieties (Table I). Since 1970, 33 new varieties with output traits (but not involving transgenes) were introduced, while approximately 165 conventional canola varieties with varying agronomic attributes targeted to specific regions and producers were launched. Beginning in 1995, genetically-modified (GM) canola crop varieties entered the Canadian market. Since then, the Canadian regulatory system has approved seven herbicide-tolerant transgenic modifications, three transgenic hybrid modifications and two modified oils. These modifications were subsequently bred into 77 commercial varieties which, together, accounted for approximately 77 percent of the Western Canadian canola acreage in 2000 (Phillips, 2003), and industry sources estimate it rose to over 80 percent in 2001 and 2002.

Meanwhile, biotechnology has accelerated the rate of development of new varieties. In the past three years an average of 30 new varieties has been introduced annually. The rapid adoption of GM varieties and the subsequent diffusion of the seed industry into a wide range of stacked input traits and differentiated novel output traits have fundamentally altered the marketing system for canola. Input trait varieties are those that improve the agronomics of the crop, such as through herbicide tolerance, while output traits are those varieties that offer attributes that generate downstream market value, such as low-cholesterol cooking oil.

Canada was the first country to identity-preserve a GM crop to ensure continued market access: this was done with GM canola in 1995-1996 (Smyth and Phillips, 2001). Given that an average 75 percent of the Western Canadian canola harvest is exported annually as seed, oil or meal, the Canadian industry found that it could not ignore the demands of global consumers and retailers.

This paper examines an array of IPPM systems for both input and output traits, and identifies unique and common costs and structures of these systems. Segregation of high erucic acid rapeseed varieties from low erucic acid canola has been necessary since canola was formally defined in 1978. Low erucic acid canola became the standard, thus forcing differing rapeseed varieties to be differentiated. Various new IPPM systems

Table I Distribution of canola varieties based on traits and marketing structures, 1970-2001

Category	No.	Breeders (number of varieties)	Key traits	Period
Non-transgenic input traits	165+	20+ various	Basic agronomic performance	1970-2001
Transgenic input traits (not requiring contract registration)	75	Advanta (5), Aventis (17), DSV Canada (6), Cargill Intermountain Canola (5), Pioneer Hi-Bred (13), Monsanto (8), Svalof (15), four others (5)	Herbicide tolerance	1995-2001
Non-transgenic output traits (not requiring contract registration)	22	Cargill Intermountain Canola (13), Dow AgroSciences (6), Pioneer Hi-Bred (1), others (2)	Specialty fatty acids and high oil content	1993-2001
Non-transgenic output traits (requiring contract registration)	11	University of Manitoba (9), Dow AgroSciences (1), Agriculture and Agri-Food Canada (1)	High erucic acid and low linolenic/high oleic acids content	1975-2001
Transgenic output traits (requiring contract registration)	2	Calgene (2)	High laurate acid content	1997-2001

Notes: Authors' estimates based on Canadian Food Inspection Agency (2002), Canola Council of Canada (2002), and Canola Guide (1999)

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have now gone well beyond the basic structure. The focus of most IPPM systems at present is to meet specific levels of purity: many markets are demanding that systems operate at 99 percent purity. The traits being segregated are, for the most part, private, proprietary assets. The public system does not and cannot undertake the job of segregating the crop, except for health and safety reasons. This article compares and contrasts the mandated and voluntary IPPM systems for input and output traits.

The conceptual framework

In a great many instances in the marketplace, neoclassical economics predicts that a simple arm's-length exchange of goods and services at an agreed price is a low-cost transaction that provides the correct incentives for buyers and sellers to exchange an optimal volume of produce. Three factors have combined to create greater complexity in the global rapeseed/canola market, causing transaction costs to rise for both buyers and sellers. In the first instance, demand has become more diffuse, as some parts of the market are only willing to pay for commodity-grade rapeseed, while other parts demand highly specific and widely differing quality, price or delivery conditions. Second, the global canola supply chain has become increasingly complex, as agronomic crop rotations have become more sophisticated and input and output markets have become globally integrated. Many inputs and semi-processed and processed outputs change hands and cross national boundaries multiple times before reaching the final consumer. Third, the rapid adoption of new technologies has contributed to a diffusion of rapeseed- and canola-related product attributes. Ultimately, these three factors have caused the global canola market, which arguably exhibited commodity attributes, to segment into a myriad of differentiated niche markets, where price discovery, negotiations and contract enforcement are increasingly time-consuming and expensive.

In essence, the attributes of many of the new canola varieties create differing levels of risk in the market. Tirole (1988) provides one route to understanding this with his three-category typology of goods:

(1) search goods, where consumers can visually identify attributes before consumption;
(2) experience goods, which require consumption to determine their attributes; and
(3) credence goods, where the unaided consumer cannot know the full attributes of consuming a good, at least for some period after consumption.

Trust is usually a key element in markets involving experience and credence goods. In practice, a single product could embody attributes that fit all three types of goods. For example, if one is looking for a tomato, one could "search" through the bins and find one that looks good, smells ripe and is apparently free of insects or disease. Once the consumer takes it home and eats it, they experience the quality of the fruit, judging it based on a variety of subjective factors, such as flavour and texture. Ultimately, the utility derived from that tomato includes any longer-term benefits or costs of consuming the product, which become known some time after consumption. These could include some benefits such as antioxidants, or some costs, such as food-borne pathogens (e.g. *E. coli* or salmonella), which would become known within a few days, or toxic elements (e.g. carcinogens) that may have only a long-term cumulative effect on a person's health.

Many new canola varieties exhibit both experiential and credence elements, involving either input traits that entail some public concern or output traits that only have value if identity-preserved. The inability to search for the attributes necessitates more managed markets. The combination of significant potential for opportunistic activity (as some producers may wish to place low-value crops into high-value markets) and high asset specificity (especially for proprietary traits or for product embodying output traits) has encouraged a wide array of managed supply chains to evolve. Table II identifies where and why three different market structures may evolve in markets such as canola. In the first instance, where there are no novel output traits or concerns related to the technology (e.g. no credence factors), spot markets are likely to be the most efficient market structure. When GM technologies are used, credence factors arise for some consumers, creating opportunities to identity-preserve and increase social welfare. Given the difficulty of searching for the differentiable traits, such identity preservation will inevitably create specific assets and ample opportunities for cheating, necessitating a more integrated, managed supply chain. Finally, all output traits, whether conventionally or transgenically inserted, will generate significant challenges that could necessitate both public and private action. The two integrated chains will differ, depending on the potential for real, measurable health and safety impacts. Where there are known or anticipated impacts, the state will inevitably reserve a role in managing the system, while, where the concerns relate to preferences, markets will probably be left to manage the system.

The economics literature provides a number of theoretical approaches to understanding how

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Table II Framework for identifying optimal market structure for new canola varieties

	Non-GM variety	GM variety
Input trait	Search good, little potential for opportunism, low asset specificity, spot markets adequate (supply chain 1 and 2)	Credence good, significant potential for opportunism, high asset specificity, IPPM required (supply chain 3)
Output trait (measurable)	Experience and/or credence good, IPPM systems frequently used to capture value (supply chain 4)	Significant potential for opportunism, high asset specificity, segregation systems required (supply chain 5)
Credence output traits (not measurable)	Dominated by audits and traceability as significant opportunity for cheating (e.g. non-GM or organic canola)	Dominated by audits and traceability as significant opportunity for cheating (e.g. socially responsible canola)

those different market structures might evolve. Two of the most significant approaches from the perspective of this paper are transaction costs and principal-agent theory. Williamson (1985) argues that two features could make arm's-length transactions costly. First, he notes that markets are best described as operating with "bounded rationality", i.e. individuals act rationally but their options are limited by imperfect information or the absence of a critical actor in a market (e.g. farmers may believe they should integrate forward into processing but a facilitating mechanism may be absent). Second, he assumes that individuals and companies may act opportunistically, i.e. they will act in a self-interested way "with guile" that increases their return, by renegotiating terms of agreements or by substituting lower-cost goods or services than contracted for. Their ability to succeed depends on their relative bargaining position, which is a function of the specificity of the assets each party has invested in the transaction. Firms with highly specific assets (i.e. those investments that have few alternate uses, such as hog barns or proprietary genes) are most at risk of having their returns bid away by other actors in the production system.

An alternative approach examines the costs and benefits of principal-agent relationships. This approach assumes that firms ("principals") will contract with "agents" to avoid market risk. Once again, there is a concern that "opportunistic" agents will take advantage of any imbalance of power, in this case resulting from the inability to measure either their contribution to the total output (called non-separability) or their inputs to the task (called task programmability). In short, the more measurement problems there are, the higher the cost of buying-in relative to the cost of doing-in, with the result that more formal vertical coordination is more likely to be pursued.

Mahoney (1992) put together the two institutional economic approaches to create a synthesized transaction cost-agency model. He argues that if one assumes opportunism, one can predict the organizational form of vertical integration based on the degree of asset specificity, task programmability and non-separability. The commodity rapeseed and canola markets traditionally exhibited low task programmability (i.e. farmers could achieve competitive results using multiple agronomic approaches), low non-separability (i.e. the value added at each stage of the production, processing and marketing of traditional rapeseed or canola could be clearly delineated) and low asset specificity (i.e. the product exhibited commodity traits in most of the transactions in the supply chain), so spot markets produced optimal volumes and prices. But as the production technologies have become more sophisticated (e.g. Roundup Ready® canola works only with specific applications of glyphosate herbicide), task-programmability has risen.

Meanwhile, recent efforts to breed in specific market characteristics have increased non-separability (i.e. the value of a low linolenic canola oil to a food processor can be affected during production, handling and processing, yet cannot be detected until used by the food processor). While many of the assets held by producers remain non-specific, some of the investments related to canola have become more specific. All of these pressures should be leading to more vertical coordination in the industry. This is exacerbated by pressures in the upstream genetics/seed business and in the related chemical industry, where asset specificity is very high and there is real pressure for increased vertical integration. Mahoney (1992) posits that with three bimodal factors (asset specificity, task programmability and non-separability), there are eight possible outcomes, each of which will exhibit an optimal organizational structure, ranging from spot markets to relational or long-term contracts, clan structures and full vertical integration through equity ownership. The optimal structure depends on the balance among the three factors.

Just which organizational structures will survive in the canola supply chain is yet to be determined. Jacquemin (1987) states that:

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... hierarchies, federations of firms, and markets compete with each other to provide coordination, allocation and monitoring. It is only when one organizational form promises for specific activities a higher net return than alternative institutional arrangements that it will survive in the long run (p. 138).

Canola production and marketing systems

A variety of identifiable types of supply chains is now operating in the canola industry in Canada and will be explained in greater detail in the following section for input traits (spot markets and voluntary general grower contracts for both non-GM and GM input traits) and for output traits (voluntary grower contracts for non-GM output traits and mandated IPPM systems for both non-GM and GM industrial output traits). There is also potential for IPPM systems to evolve to handle new canola varieties with credence elements (as noted in Table II). For example, there have been some attempts to develop organic canola (which averaged about 420 tonnes annually in 1996-2000 in Canada), non-GM canola and socially responsible varieties (which could be non-GM or GM). There is no reliable evidence of how these systems could operate, so they are not considered below.

The data for this paper was gathered between 1997 and 2001 from numerous public and private sources. Public variety data was gathered and analyzed from the Canola Council of Canada. A survey was sent to Aventis, Dow AgroSciences and Monsanto, in 1999, to determine the importance of intellectual property rights, quality assurance and identity preservation in supply chain development. Several interviews were conducted with Agriculture and Agri-Food Canada researchers to gather the remainder of the information needed for this case study. Industry participation was crucial for this case study, as several private seed development firms provided information that was not otherwise available.

Supply chains for input-trait canola

The three models of supply chains for canola (Table III) with input traits operating in Canada during the 1990s are all voluntary. The first type is based on spot markets throughout the supply chain. This is a non-proprietary system, which, for the most part, involves public or non-proprietary varieties (e.g. AC-Excel), uses spot markets to effect the transfer of inputs and product, and conforms with the public grading system established through the Seeds Act and the Canadian Grain Commission.

The second type of supply chain that emerged during the 1990s involved a wide number of proprietary producer contract systems. In these cases, a grain merchant (e.g. Value Added Seeds) acquires access to a new variety (e.g. Settler) that has the potential to gain market share, and makes that variety available to growers only under a production input and delivery contract. In short, the grower buys a package of inputs (seed, fertilizer and herbicide) from the grain merchant, which finances the transaction until the grower delivers the resulting harvest to the merchant. The objective of this type of arrangement is to lock in input sales and output volumes. In the late 1990s, these types of contracts were worth as much as C$50 per acre (Beard, 2001)[1]. These contracts tended to be open-ended pricing arrangements, with provisions for growers to lock in delivery prices based on futures prices. Unlike many of the other contracts in the industry, grower obligations are usually limited to the specific product contracted and do not in any way restrict the production of other varieties of canola on the grower's farm. In effect, these contracts exist only where there are both corporate benefits and farmer returns.

The third system evolved in 1995 with the introduction of two herbicide-tolerant (HT) varieties of canola. Under Canadian law, new GM varieties that meet Canadian health, safety, environmental, feed and seed regulations are approved for unconfined commercial release regardless of any potential market difficulties. In 1995, Canadian approval came before the key export markets had approved the seed for importation. An earlier paper (Smyth and Phillips, 2001) documented the IPPM systems that evolved to handle the market risks of these new varieties. Between 1995 and 1999, Monsanto and AgrEvo (now Aventis) were involved in five systems that identity-preserved ten GM varieties on approximately 385,000 acres (Smyth and Phillips, 2001).

Each of the supply chains began with a specific variety which included a proprietary herbicide-tolerant gene which was backcrossed or inserted into a plant by either a contract breeder or a partner company (e.g. Agriculture and Agri-Food Canada, Plant Genetics System, University of Alberta, Alberta Pool Elevators, Limagrain, Pioneer Hi-Bred or Zeneca/Advanta). Once this variety was registered, Monsanto or AgrEvo contracted with one of the grain merchants (one of the Pools, United Grain Growers or Cargill)[2] to manage the development and management of an IPPM system. That company then multiplied the seed, undertook production contracts with specific farmers, arranged delivery from farms to a processor with contract truckers, and arranged for

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Table III Illustrative examples of types of supply chains in the Canadian canola industry, 1990-2001

	Non-GM input traits		GM input trait	Non-GM output traits	GM output trait
Regulatory base	Variety standards in Seeds Act and Trade mark for canola			Variety standards and contract registration rules in Seeds Act and Trade mark for canola	
Type/source	1	2	3	4	5
Illustrative variety(ies)	AC-Excel	Settler	Innovator, Independence, 3850 and 3880	DMS-100	LA 161, LA 269
Special trait	None	None	LibertyLink® gene	Specialty oil	Laurate gene
Dates	1991-2001	1994-2001	1995-1996	1997-2001	1997-1999
Marketing mechanism	Spot market	Spot market, input packages, commodity futures	Management contract with Pools, grower contracts, CCC activity	Contracts with Pioneer Grain and Canbra, plus grower contracts	Grower contracts
Seed developer	AAFC	Svalof Weibull, Pioneer and Hi-Bred	AAFC and PGS for AgrEvo	Dow AgroSciences	Calgene/Saskatchewan Wheat Pool
Grain merchant	Various	Value Added Seeds	Saskatchewan, Alberta and Manitoba Pools	Pioneer Grain (JRI)	Saskatchewan Wheat Pool
Acres	~500,000	<200,000	215,000	<150,000	<30,000
Growers	~5,000	<2,000	<2,700	<1,000	<300
Grower premium	None	Financing	Estimate C$2 per acre savings on inputs	C$40 per tonne plus C$2.50 per tonne storage costs	C$35 per tonne
Transport	Growers truck to crusher or elevator, grain company manages rail	Growers truck to crusher or elevator; grain company manages rail	Commercial trucking to crusher arranged by Pools	Commercial trucking to crusher arranged by Pioneer, Canbra and growers	Commercial trucking to crusher arranged by Saskatchewan Wheat Pool
Crushers	Four companies, seven locations in Western Canada	Four companies, seven locations in Western Canada	Canbra at Lethbridge, Alberta; CanAmera at Altona, Manitoba and Harrowby, Alberta	Canbra Foods at Lethbridge, Alberta	CanAmera at Altona, Manitoba
Marketing arrangement	Seed, oil, meal shipped to any of 35 markets by various agents	Value Added Seeds arranged sale of seed either domestically or offshore	XCAN directed oil and meal to North American market	Pioneer Grain (JRI) arranged sale of seed to Japan	Calgene arranged sale of oil to USA, meal was used as green manure or destroyed

Notes: t = metric tonne; CCC = Canola Council of Canada; AAFC = Agriculture and Agri-Food Canada; PGS = Plant Genetics Systems; JRI = James Richardson International; Pools = the combined actions of the Alberta Pool Elevators, the Saskatchewan Wheat Pool and the Manitoba Pool Elevator
Sources: 1, Authors' estimates; 2, Allen (1999); 3, Kennedy (1999a); 4, Kennedy (1999b), 5, Saskatchewan Wheat Pool (1999)

a custom crush, identity preservation and diversion of the resulting oil and meal into the North American market. As the objective of the IPPM system was to identity-preserve the herbicide-tolerant canola from traditional canola marketing channels, none of the GM canola could touch any part of the export handling system, including elevators, rail cars or port terminals. The identity-preserved GM production was delivered to Canadian oilseed crushing plants that had markets for the oil and meal in Canada and the USA, where regulatory approval had been granted (Saskatchewan Wheat Pool, 1997). In each case, the grain merchant acted as the operating agent for the system, managing the supply chain from seed multiplication to processing.

Although the resulting IPPM systems cost an estimated C$33-41 per tonne[3] (Manitoba Pool Elevators, 1996; Saskatchewan Wheat Pool, 1997) and the varieties did not yield any premium in the market, the participants in these IPPM systems all agreed that the herbicide-resistant technology brought real value to the sector and to producers, and all agreed to participate in the IPPM system in order to quickly bring the technology into the marketplace. Farmers were estimated to have earned a small increment over traditional varieties, after paying for small inefficiencies owing to on-farm segregation. The grain companies and crushers estimate they were out of pocket about a few dollars per tonne, but they accepted those losses to lock in access to the new germplasm. AgrEvo and Monsanto spent C$20 per tonne on the IPPM systems but gained an estimated net present value of C$100 million through accelerated adoption (Smyth and Phillips, 2001).

Supply chains for output-trait canola

The two main types of supply chain for canola with output traits operating in Canada during the 1990s were required by law because of the potential health and safety risks of the novel traits involved. A few IPPM systems for proprietary non-novel trait varieties have operated (i.e. not mandated by law), but no details are available.

The fourth type of supply chain is designed to handle both commercial interests and public health and safety concerns about the novel attributes in the varieties, in order to allow the production of both food-grade canola and industrial rapeseed at the same time. The fundamental driver for this system is food safety. Some products, such as high erucic acid varieties and Dow AgroSciences' DSM-100 (which has low linolenic and high oleic acids), would contaminate the food chain if co-mingled and are therefore mandated by law (via Contract Registration under the Seeds Act) to be produced under segregation rules. Dow, for instance, developed through traditional breeding processes a variety of canola that has a novel oil output trait designed to meet processor and consumer demand for an edible oil product that is low in saturated fats. They developed the seed themselves and introduced it to the marketplace in 1997 through marketing arrangements with Pioneer Grain. Dow contracted with Pioneer to multiply the seed and to introduce the seed into the market through production contracts, which, for DSM-100, specified the inputs to be used, compulsory delivery, a producer premium of $40 per tonne, a producer storage subsidy for late season deliveries of $2.50 per tonne (paid by the Japanese importer) and restrictions on other canola crops on the land. In addition, the grain merchant assembled the resulting crop and arranged export of the product.

This system was explicitly designed to ensure delivery of a product which met or exceeded the end customer specifications. Although not the primary objective, the company admits that the IPPM system provides a vehicle to protect their intellectual property. During the first three years of operation, the company asserts it was able to both lower costs and improve efficiencies on an annual basis. Dow believes that the skills and techniques they are developing from their experiences have provided value and help to create a competitive advantage.

The fifth type of supply chain, which involves a canola variety that possesses both genetic modifications and novel industrial output traits, is similar to the fourth type. Calgene's relationship with the Saskatchewan Wheat Pool to manage the production, delivery and crushing of Laurical™ canola varieties illustrates the challenges of this type of system. As for DSM-100, laurate canola is mandated by law to be produced under a segregation regime. But, being a "novel trait" variety, the seed required additional testing for environmental, food and feed safety impact, compared with DSM-100, with the result that the development costs were raised. Meanwhile, laurate is a relatively low-value oil and Calgene and the Saskatchewan Wheat Pool discovered that the $35 per tonne grower premium (paid to compensate for lower yield and tight restrictions on other plantings of canola) and the incremental segregation costs more than offset any premium for the oil, with the result that the variety ceased to be produced in 1999.

Supply chain governance mechanisms

Quality in the canola industry has historically been managed and protected through a wide variety of open-access horizontal mechanisms. Increasingly, however, these systems are being supplemented and at times supplanted by proprietary vertical relationships. So far, the new systems have

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facilitated new product development, but at times in an unsustainable way.

The traditional governance system is based on an extensive horizontally-based public/private regulatory system (Altman and Phillips, 2001; Smyth and Phillips, 2002b). The Seeds Act is the first point of quality assurance, as new varieties must, on average, at least equal the quality of previous varieties. This is administered by the Western Canadian Canola Rapeseed Recommendation Committee (WCCRRC), a committee of more than 30 public and private breeders, which evaluates new varieties against a historical "check" variety and recommends varieties for release. This standard has been backstopped by the Canola Council of Canada trademark on canola, which specifies that products must have, at most, 2 percent erucic acid and 30 micromoles of glucosinolates per 100 grams of dried meal. Furthermore, the new variety approval system periodically raises the bar for new varieties by choosing a new "check" variety as the base for standards, which sets the base for oil and meal properties, yields and disease resistance.

Once the varieties are approved, the Canadian Seed Trade Association manages the seed multiplication system, specifying the tolerances for substandard materials, and the retail seed business, by overseeing the sale of seeds by registered name. The Canola Council of Canada, the provincial growers' associations and various provincial government agencies support this system with extensive agronomic extension advice to growers during the season. After the harvest, the Canadian Grain Commission takes over quality assurance for much of the product, setting and enforcing grades and standards for the trade. The Canola Council of Canada, a not-for-profit industry association involving growers, grain merchants, crushers and exporters, ultimately oversees the entire system by licensing and defending its use of the canola trademark. Within this context, spot markets have, over the years, relatively efficiently managed the commercialization of a large number of new varieties (Kennett *et al.*, 1998).

As the spot market has been supplanted by new vertical supply chains, quality is increasingly being managed by and for private interests. For example, the growers' contract, which provides the base for all of these new systems, specifies a variety of obligations and quality standards that manage the value of the new product within the supply chain. This has included agronomic advice tailored to specific proprietary varieties. Meanwhile, vertical relationships extend back from the grain merchant to the seed and research companies and, in some instances, forward from the crusher into the processed foods sector. This trend has been supported with recent changes in the Canadian regulatory system which allow for accelerated contract registration for new proprietary novel-trait varieties without going through full review by the WCCRRC.

As new proprietary supply chains have proliferated, a number of difficulties have surfaced. In interviews, company officials note that there is a critical need to have the ability to rapidly analyze grower deliveries at the consolidation point to ensure the product meets specifications and is not co-mingled with other materials. Given the traits involved, the companies are unable to assure quality adequately. Furthermore, there needs to be more capability to identity-preserve various products into more manageable and cost-effective units. Most companies agree that many of the new products being considered cannot be justified if the identity preservation system continues to cost up to C$40 per tonne. In part, this IPPM system was costly owing to the requirement that all the GM canola be contained in the North American market, and there were no allowances for adventitious co-mingling in the international marketplace. The majority of the new structures being developed (both elevator buildings and handling systems) are not cost-efficient in handling small-lot, non-commodity movements.

Farmer training also remains a challenge. Teaching growers to have a "quality mindset" versus a "quantity mindset" is a key challenge in Canadian agriculture. Although the information required to assist farmers with growing specific varieties is often only available from the research companies, the focus on quality requires some horizontal effort.

Finally, it is interesting to note that, so far, industry-based quality assurance has been very limited. Apart from the role of the Canola Council of Canada in assuring Japanese customers of the integrity of the AgrEvo/Monsanto IPPM systems in 1995-1999 (Smyth and Phillips, 2001), there has been no focused effort on developing common quality assurance systems with credible third-party audits. Agriculture and Agri-Food Canada (2002) announced plans to implement a national program of on-farm quality assurance, but there is no information yet on how it will be managed and or how it will link to the rest of the agri-food supply chain.

Conclusion

Biotechnology innovations in agriculture present a clear challenge to the traditional marketing system. Transactions for new, proprietary, novel-trait canola varieties require a more extensive set of institutions than are required for traditional

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commodity varieties. Rising asset specificity, task programmability and non-separability in the canola industry are bringing forth a variety of new market structures. Companies, assisted by governments and industry associations, have developed a range of IPPM systems that both handle the risks and assist with capturing the returns from the introduction of new products with commercially valuable input and output traits. As such, spot markets for canola are increasingly competing with proprietary, vertically integrated supply chains. The optimal structure and organization of these new supply chains has not evolved yet, but over time one would expect a more stable set of relationships to emerge.

Identity-preserved production and marketing systems would appear to have become a significant, permanent feature in the canola industry. If they are to expand their impact, however, they will need to become more efficient. Identity-preserved production and marketing systems appear to be technically feasible for smaller units of production, but it is unclear whether that they are economically viable either in the long-term or for larger-scale operations. Some stakeholders believe that if an IPPM system were spread over a much larger production base, efficiencies would be possible, while others believe that there are too many supply constraints (e.g. trucking and storage) for it to work. If IPPM systems continue to cost C$30-40 per tonne, investment in input traits could wane and the effort devoted to seeking output traits could shift to only higher-value attributes.

So far, all of the IPPM systems developed have been custom-built to meet the specifications of the technology owner and the market. The limited horizontal coordination between the systems has come through the seed companies (e.g. Monsanto and AgrEvo) working with their agents (the grain companies) and through the Canola Council of Canada's efforts in export markets. For the most part, the grain companies have viewed the IPPM systems as valuable proprietary services. Ultimately, however, these systems are designed to earn trust. But trust is a cumulative process, where past successful actions can contribute to achieving a higher level of trust. Conversely, failures in one part of the market can spill over to other market segments. If IPPM is here to stay, then it may not be enough to rely on independent systems.

One of the leading concerns of the new biotechnology-derived crops is the management of the risks and liabilities associated with these new crops. Identity-preserved production and marketing systems can provide an effective and proven method of controlling risks and liabilities. When properly structured and carefully administered, IPPM systems are capable of operating at a purity rate of 98-99 percent. However, product differentiation systems that are not properly structured and are poorly administered, such as the system initiated by Aventis to manage StarLink® corn, can have a detrimental impact on the entire industry for that product.

The key to ensuring that IPPM systems can operate effectively will be realistic tolerance levels for adventitious and accidental co-mingling, effective monitoring and auditing and new risk management tools. Within any IPPM system, mistakes are going to occur, and when they do the system must have the flexibility to be able to continue operating while the source of the undesired co-mingling is determined. Furthermore, there may need to be some insurance mechanism put into place to compensate producers, in particular for adventitious co-mingling and the resulting loss of crop value. More work is needed to delineate all of these factors.

Notes

1. This value is comprised of interest-free financing costs for the purchase of inputs, typically until the end of October each year, and the ability of the contractor to advantageously lock in delivery prices at any time prior to the completion of the harvest.
2. In 1995, the Pools represented the joint actions of the Manitoba Pool Elevators, Saskatchewan Wheat Pool and the Alberta Pool Elevators. In 1998, the Manitoba and Alberta Pools merged to form Agricore. In 2001, Agricore merged with United Grain Growers to form United Agricore.
3. This cost figure is comprised of inefficient on-farm storage ($1), freight inefficiency ($5-10), dead freight ($1-3), cost of processing ($3-5), administration ($4-5), and opportunity cost ($15-20).

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