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The Gene Technology Regulator's approval of Bayer® CropScience's® genetically modified (GM) canola variety, InVigor®, and of Monsanto's® Roundup Ready®, means that the commercial planting of Australia's first GM food crop is imminent. Under such circumstances, for Australia to continue marketing non-GM canola and comply with worldwide labelling requirements segregation must be implemented. This study investigates the cost effectiveness of three possible segregation methods. In considering each of these methods the increase in total grain handling cost due to segregation is expected to be between 5 and 9 per cent, or $1.34/tonne and $2.70/tonne. Such an increase is comparable with segregation costs reported in current Canadian literature.

Keywords: GM canola, segregation, supply chain.

## 1. Introduction

Excluding intra-European Union trade, Australia is the second largest exporter of canola worldwide, with 14 per cent of the market while Canada, the largest exporter, has 44 per cent of the market (Leading Dog Consulting & Synecon Pty Ltd, 2001). Western Australia exports 93 per cent of its canola crop, worth $180.3 million, with 99.7 per cent going to Japan, China, Pakistan and Malaysia in 2001/02 (Dept. Ag WA, 2003). The focus of this study was on the Great Southern Region of WA where according to Cooperative Bulk Handling (CBH, 2003), 176, 000 tonnes, around 40 per cent of the total WA canola crop, were expected in 2003.

Canada's canola production is not segregated as their major export markets, Japan and China, do not currently require non-GM identity preservation and are not willing to pay a premium for non-GM canola (AOF, 2003b; Leading Dog Consulting & Peter Flottmann and Associates, 2001). Canada has not exported canola to the European Union (EU) since 1995 as a consequence of the introduction of GM canola to Canada (GMCTWG, 2001). The GM Canola Technical Working Group (GMCTWG, 2001) believe the EU market to be significant to Australia but as the EU accounts for around 1 per cent of WA's canola exports (Dept. Ag WA, 2003) this is questionable. Nevertheless, to ensure minimal impact on the WA canola industry and markets and to provide a flexible position to respond to changes in acceptance of GM canola by major export customers, segregation of GM and non-GM canola will be important to the canola industry (Dept. Ag WA, 2003).

The commercial release of GM canola in Australia will see the first GM crop to be grown for human consumption in Australia (OGTR, 2003b). The Gene Technology Regulator, Sue Meek, on 25 July 2003 approved as safe for humans and the environment the GM canola Bayer® CropScience's® InVigor®, a canola variety genetically modified to be resistant to the herbicide LibertyLink® (gluphosinate) (OGTR, 2003a). Monsanto's® Roundup Ready® canola variety, genetically modified to be resistant to the herbicide Roundup® (glyphosate), was approved by the Gene Regulator on 19 December 2003 (OGTR, 2003c). However, as all canola growing States currently have a moratorium preventing the release of GM canola for broad-scale agriculture, commercial release is potentially stalled.

Cooperative Bulk Handling, however, who controls the handling, transport and storage of grain from grower delivery to export in WA, believe that segregation is already a long-term issue irrespective of GM crops (Collis, 2003). Contamination of non-GM products by GM seed is most likely to occur due to physical seed movement, especially if GM and non-GM canola share a supply chain (AOF, 2003a). Furthermore, new conventionally breed varieties would not suit Australia's current grading system based on visual characteristics of the grain (Collis, 2003). Who will bear the cost of segregation depends on the price responsiveness of demand and supply, availability of substitutes, market structure and agricultural price policy (Europa, 2003). This question was not addressed in this study but rather the cost of segregation given three different scenarios was explored.

## 2. Segregation

Smyth and Phillips (2002) define segregation, identity preservation and traceability based on the work of Picciotto (1995), highlighting the inter-relatedness of the three preservation systems, as shown in Figure 1. Segregation is defined as a requirement of regulatory approval that is mandated upon those participating in the system, to be used when potential food safety concerns exist over the commingling of the segregated product and all other like products (Smyth & Phillips, 2002). An identity preservation production and marketing system in contrast is a volunteer system used by private firms to capture the added value associated with the commodity or product (Smyth & Phillips, 2002). Traceability is the ability to trace the history, application or location of an entity by means of recorded identifications (Smyth & Phillips, 2002). The differentiation of GM and non-GM canola within the Western Australian supply chain is section F of Figure 1. For the purposes of this study this section is referred to as a segregation system, although it is technically an identity preservation production and marketing system.

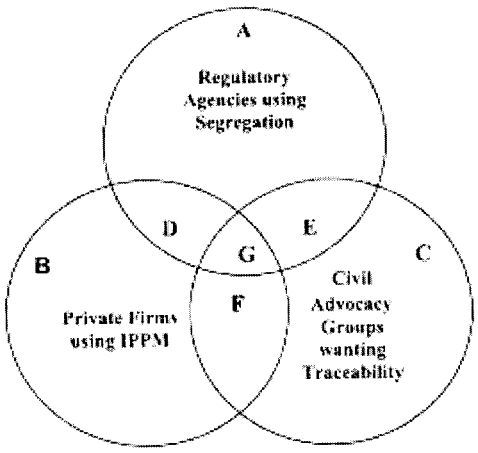


**Figure 1. Interrelation between an identity preservation production and marketing system, segregation and traceability (Picciotto, 1995).**

Canada segregates grain for niche markets such as the British baker Warburtons' wheat contract program, and the Canadian Wheat Board's malting barley and AC Karma contracts (Canadian Grain Commission, 1998; Bevilacqua, 1999). Canadian estimates of canola

segregation costs range from 6-41 per cent of the producer price for conventional canola or in Canadian dollars $10-50 (Europa, 2003; Golder, 2000). These cost estimates are possibly underestimating the true value, as they are based on small volumes, are not significant operations and also do not recognise the loss of the organic canola market in Canada (Smyth & Phillips, 2002). The cost for segregation in the US, Brazil and the EU is estimated to be between 5 and 15 per cent of the farm gate price (Kingwell, 2000). Based on global estimates of segregation it is expected that the cost of segregating GM and non-GM canola in the Great Southern Region of WA, from farm-gate to Albany Port, will approximate world estimates of a 10 to 11 per cent increase.

## 3. Methodology

Cost effectiveness analysis is based on the calculation of the present value of cost flows over time for alternative projects and comparisons made between these values. The three scenarios identified were based on discussions held with David Fienberg[1] into the likely receival patterns of CBH following the commercial release of GM canola and historical receivals of canola by CBH. The first scenario involved BroomeHill and Albany Port being dedicated to receive GM canola only, and all other receival points being dedicated to receive non-GM canola only. Albany Port was assumed to receive GM and non-GM canola, but the two varieties would be completely separated. This scenario is referred to as the 'dedicated' receival system and indicates the possible receival system if receival points were to be devoted to GM or non-GM only. The second scenario was a shared receival system, whereby all receival points across the Great Southern Region took delivery of both GM and non-GM canola. The second scenario is referred to as the 'shared' receival system and indicates the receival system if receival points are to share handling and storage facilities at receival points. The third scenario, the 'Albany' receival system involved GM canola being delivered only to the Albany Port, with all other receival points dedicated to receive non-GM canola only.

An initial model was constructed to identify the total cost of handling, transport and storage post-farm gate to Albany Port for all canola in the Great Southern Region under the three segregated receival system scenarios, as well as, without segregation. The costs of handling, transport and storage that would be incurred regardless of segregation were removed from the three receival system models, providing the increase in cost due to the implementation of each segregation system. The NPV of the costs was calculated over a 10 year period to allow for a stable GM adoption level to be achieved and the full costs of the implementation and maintenance of the segregation system to be realised. All costs were initially identified on a per tonne basis and then delineated for the entire Great Southern Region's canola production. The costs identified for each receival system scenario were based on the work of Bullock *et al.* (2000) and Fulton *et al.* (2001).

### *3.1 Regional Production*

The hectares of canola produced in the GSR (H) is equal to the product of the total number of grain growers in the GSR (G), percentage of growers who plant canola ($\alpha$), the expected increase in adoption over time ($\beta_1$) and the average hectares of canola planted by each grower (h).

$$H = G\,\beta_1 \alpha\, h \qquad (1)$$

[1] David Fienberg is the Manager of Supply Chain Quality at CBH/GrainPool.

The hectares of GM canola produced in the GSR (D) is the product of the hectares of canola produced in the GSR (H), the percentage of canola growers planting GM canola (A), increase in adoption of GM canola ($\beta_2$), the maximum percentage of canola area GM adopters chose to plant to GM canola on his/her farm ($\gamma$) and the increase in GM area planted over time ($\beta_3$).

$$D = H\,\beta_2 A\,\beta_3\gamma \qquad (2)$$

The hectares of non-GM canola planted by GM adopters (E) accounts for the percentage of their canola crop they do not plant to GM canola ($1 - \beta_3\gamma$).

$$E = H\,\beta_2 A\,(1 - \beta_3\gamma) \qquad (3)$$

The hectares of non-GM canola planted by non-GM canola growers (F) recognises the percentage of canola growers not adopting GM canola ($1 - \beta_2 A$).

$$F = H\,(1 - \beta_2 A) \qquad (4)$$

The yield of GM canola in tonnes per ha (Z) is the product of the tonnes per ha of non-GM canola (Y) and the percentage yield advantage GM canola offers over non-GM canola ($\mu$)[2].

$$Z = Y\,\mu \qquad (5)$$

The quantity of GM canola produced in tonnes (M) is the product of equations 2 and 5.

$$M = Z\,D \qquad (6)$$

The quantity of non-GM canola produced in tonnes (N) is found by adding equations 3 and 4 and multiplying by the yield of non-GM canola in t/ha (Y)

$$N = (E + F)\,Y \qquad (7)$$

The total canola production of the GSR in tonnes (Q) is the sum equations 6 and 7.

$$Q = M + N \qquad (8)$$

### *3.2 Production and Receivals*

Canola production and grower delivery behaviour across the Great Southern Region varies between shires with Jerramungup producing the highest quantity of canola, 22,400 t annually on average or 16 per cent of the Great Southern Region's production, and Tambellup the lowest, 6,200t or 5 per cent (Table 1). CBH receivals of canola are not evenly distributed across the region, or matched with shire production. Albany receives the greatest proportion of the Great Southern Region's production, 64,300t or 46 per cent annually on average, while Plantagenet and Tambellup do not receive any canola (Table 1).

[2] The yield of GM canola is not reduced when initially grown, as occurs with some variety introductions, as it is very similar to current canola varieties so no additional production knowledge will be required by the grower (Alcock[2] pers. comm., 2003).

**Table 1. Canola production and canola receivals by CBH in the Great Southern Region by Shire.**

| Shire | Avg Production (t)[1] | Prodn % of GSR | Avg Receivals (t)[1] | Recv % of GSR |
|---|---|---|---|---|
| Albany | 13,100 | 9 per cent | 64,300 | 46 per cent |
| BroomeHill | 7,500 | 5 per cent | 11,600 | 8 per cent |
| Cranbrook | 15,000 | 10 per cent | 16,100 | 11 per cent |
| Gnowangerup | 18,700 | 13 per cent | 11,400 | 8 per cent |
| Jerramungup | 22,400 | 16 per cent | 14,000 | 10 per cent |
| Katanning | 11,309 | 8 per cent | 8,200 | 6 per cent |
| Kent | 8,600 | 6 per cent | 3,900 | 3 per cent |
| Kojonup | 14,200 | 10 per cent | 9,300 | 7 per cent |
| Plantagenet | 17,900 | 13 per cent | - | - |
| Tambellup | 6,200 | 4 per cent | - | - |
| Woodanilling | 8,000 | 6 per cent | 2,000 | 1 per cent |
| Total (GSR) | 143,000 | | 140,700 | |

[1] Average taken over 1999, 2000, 2001 and 2002. Data provided by CBH.

Therefore the following equations were developed to explain grower delivery behaviour. Shire k's production of GM canola ($m_k$) and non-GM canola ($n_k$) in tonnes, is calculated as the average percentage of production of that shire ($\eta_k$), multiplied by the corresponding GM (M) or non-GM (N) canola production in tonnes of the GSR from equations 6 and 7 respectively. Total canola production of shire k in tonnes ($q_k$) is therefore the sum of the tonnes of GM ($m_k$) and non-GM ($n_k$) canola production. CBH receivals in shire k, in tonnes, of GM canola ($w_k$) and non-GM canola ($x_k$) is calculated as the sum of; the percentage of production of each shire delivered to shire k ($\varsigma_k$), multiplied by the production of GM ($m_k$) or non-GM ($n_k$) canola by each shire from equation 9 and 10, and the percentage of production delivered to CBH ($\varepsilon$). Total receivals of canola by CBH in shire k ($r_k$) is the sum of GM canola receivals ($w_k$) and non-GM canola receivals ($x_k$) and is equal also to the sum of; the percentage of production of each shire delivered to shire k ($\varsigma_k$), multiplied by the production of canola ($q_k$) by each shire, and the percentage of production delivered to CBH ($\varepsilon$).

$$m_k = \eta_k M \quad (9)$$
$$n_k = \eta_k N \quad (10)$$
$$q_k = m_k + n_k = \eta_k Q \quad (11)$$

$$w_k = \sum (\varsigma_k \varepsilon m_k) \quad (12)$$
$$x_k = \sum (\varsigma_k \varepsilon n_k) \quad (13)$$
$$r_k = w_k + x_k = \sum (\varsigma_k \varepsilon q_k) \quad (14)$$

Total receivals by CBH for the GSR in tonnes of GM (W) and non-GM (X) canola is calculated as the sum of the receivals of each shire ($w_k$ and $x_k$ respectively) and is equivalent to the total production in tonnes of the GSR (M or N), multiplied by the percentage of grower production delivered to CBH ($\varepsilon$). The total canola receivals (R) of the GSR is equal to the sum of total production for each shire ($q_k$), or the total production of the GSR (Q) multiplied by the percentage of grower production delivered to CBH ($\varepsilon$).

$$W = \sum w_k = M \varepsilon \quad (15)$$
$$X = \sum x_k = N \varepsilon \quad (16)$$
$$R = \sum q_k \varepsilon = Q \varepsilon \quad (17)$$

### *3.3 Costs Incurred*

The cost of cleaning a truck post GM-canola transport is calculated as the product of the cost of labour in \$/hr (L), the time involved in hours ($t_{Truck}$), the number of tonnes of GM canola produced by the GSR (M) divided by the average capacity of a truck or section of truck in

tonnes ($T_{Truck}$) and the total tonnes of GM canola production in the GSR (M) from equation 6. The opportunity costs associated with the inconvenience of cleaning, primarily lost efficiency ($C_{OTruck}$) is simply equivalent to $C_{Truck}$. This cost was borne equally by all three segregation systems investigated.

$$C_{Truck} = (L\ t_{Truck}) / T_{Truck})\ M \qquad (18)$$

The cost of testing ($C_{Test}$) is incurred by all three scenarios and includes the cost of each test ($C_{Samp}$) and the product of the cost of labour in \$/hr (L) and the time involved in hours for each test ($t_{Samp}$), divided by the average capacity of a truck ($T_{Truck}$), multiplied by equation 16. Factor $\beta_4$ accounts for the cost of learning about the new testing equipment and procedures. The opportunity cost of the test ($C_{OTest}$) is equal to the cost of the test ($C_{Test}$) and represents the inconvenience and inefficiency caused by the testing. The opportunity cost of lost storage capacity ($C_{OCap}$) is calculated as the product of the lost capacity of the storage facilities in tonnes ($K_{Stor}$), the capital value of the storage in \$/tonne ($V_{Stor}$) and the number of sites affected ($N_{Sites}$).

$$C_{Test} = ([C_{Samp} + (L\ \beta_4 t_{Samp})] / T_{Truck})\ X \qquad (19)$$

$$C_{OCap} = K_{Stor}\ V_{Stor}\ N_{Sites} \qquad (20)$$

The shared system incurs additional costs due to increased cleaning and management requirements. The cost of cleaning equipment and storage facilities ($C_{Clean}$) and the cost of management time ($C_{Mang}$) are calculated as the product of the cost of labour in \$/hr (L), the time involved in hours ($t_{Clean}$; $t_{Mang}$) and the quantity of GM canola received by CBH, W (equation 15). The factors $\beta_5$ and $\beta_7$ indicate the increased time taken to teach and learn the new cleaning equipment and procedures when initially introduced. $\beta_6$ indicates that management would receive a higher wage, proportional to the wage of the lower wage casual employees. The opportunity cost associated with the loss of efficiency as resources are reallocated ($C_{Oclean}$; $C_{OMang}$) are simply made equal to the actual costs.

$$C_{Clean} = (L\ \beta_5 t_{Clean})\ W \qquad (21)$$

$$C_{Mang} = (\beta_6 L\ \beta_7 t_{Mang})\ W \qquad (22)$$

If contamination has occurred during storage at the receival point it must be identified before transportation to port. This means that with the shared segregation system non-GM canola is required to be tested again prior to transport to port. These costs are calculated using equation 19 and the associated opportunity cost.

The consequence of contamination occurring at the receival point with the shared segregation system is a loss of premium for the proportion of non-GM canola affected. The loss of premium ($C_{Con}$) is calculated as the product of the probability of contamination occurring as a percentage ($\omega$), the tonnes of non-GM canola received in the GSR, X (equation 16) and premium available for non-GM canola in \$/tonnes (J).

$$C_{Con} = \omega\ X\ J \qquad (23)$$

The dedicated system has the additional costs of indirect delivery as some growers must deliver their canola to a receival point further from Albany than their origin, cleaning of the train carriage or truck post-GM canola transport, and the opportunity costs due to the inconvenience of these activities. The cleaning cost ($C_{Train}$) is based on equation 18, except the average capacity of the train cleaned ($T_{Train}$) replaces the average capacity of the truck. The opportunity cost of cleaning the train ($C_{OTrain}$) is equivalent to ($C_{Train}$). The additional cost per tonne, due to indirect delivery ($C_{IDel}$) is calculated as twice the cost of freight from the

farm in shire k to BroomeHill ($B_k$ - $B_{BH}$) multiplied by $x_k$ (equation 13 ) and the percentage of shire k production redirected ($\xi_k$). The opportunity cost of indirect delivery ($C_{OIDel}$) is equivalent to ($C_{IDel}$).

$$C_{Train} = (L\ t_{Train}) / T_{Train})\ M \quad (24)$$

$$C_{IDel} = \sum[2\ |B_{BH} - B_k|\ x_k\ \xi_k] \quad (25)$$

A dedicated receival system also incurs opportunity costs due to the inability of growers to deliver non-GM canola to BroomeHill ($C_{ORDel}$), and the additional deliveries of GM canola to BroomeHill ($C_{OADelBH}$) and Albany ($C_{OADelA}$). These opportunity costs are calculated as the product of the percentage of canola being redirected for each shire ($\xi_k$), the GM ($w_k$) or non-GM ($x_k$) canola receivals from shire k in tonnes, the cost of freight between the two shires involved in \$/tonne ($B_{BH}$ or $B_A$, and $B_k$) and a factor for the possible overestimation of the inconvenience by this method ($\beta_8$)[3]. The proportion of canola redirected is calculated as the difference between the percentage delivered on average by growers compared to the percentage they are forecast to deliver under the altered receival system.

$$C_{ORDel} = \beta_8 \sum[(B_{BH} - B_k)\ x_k\ \xi_k] \quad (26)$$

$$C_{OADelAl} = \beta_8 \sum[(B_{Al} - B_k)\ w_k\ \xi_k] \quad (27)$$

$$C_{OADelBH} = \beta_8 \sum[(B_{BH} - B_k)\ w_k\ \xi_k] \quad (28)$$

At Albany Port the non-GM canola is again tested prior to shipment to guarantee the tolerance levels required by the exporter have been achieved and is equivalent to $C_{Test}$ (equation 19) and the associated opportunity cost.

### *3.4 Net Present Value*

The net present value (NPV) is calculated as below where n is the number of cash flows, i is the number of years, total cost is the sum of all costs incurred in period i and $\alpha$ is the discount rate applied. The discount rate applied is equal to 1 + current interest rate offered by banks on investments

$$NPV = \sum_{i=1}^{n} [(\text{total cost}_i / (\alpha)^i] \quad (29)$$

## 4. Application

A sample of 600 was taken from a random selection of 3000 residents listed in the WhitePages® directory for the Great Southern Region of WA. The Great Southern Region was selected as it is the predominant canola growing region of WA (CBH, 2003) with around 1,100[4] grain growers. The survey was designed to find grower production and delivery behaviour, attitudes towards GM issues and intention to adopt canola genetically modified for herbicide resistance. The survey package sent to growers consisted of a cover letter, a non-response form, a questionnaire, and a reply paid envelope. The non-response or gold form allowed the recipient to indicate why they did not complete the questionnaire so non-response could be more accurately explained and any non-response bias recognised.

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[3] $\beta_8$ is an arbitrary number chosen to indicate that the opportunity cost to growers would be less than the cost incurred as they are only inconvenienced not required to pay twice for delivery.

[4] Deduced from data provided by the Australian Bureau of Statistics, CBH and the grower survey.

Data gathered from the survey was combined with that from CBH (2003), the Elders Farm Weekly Farm Budget Guide 2003 (2003) and the Australian Oilseeds Federation (2003a; 2003b) and entered to solve the equations presented above in Section 3. In calculating the net present values the costs were calculated on an annual basis, discounted (applying a current interest rate of 4 per cent) and summed for a 10 year time frame.

## 5. Results and Discussion

Just below 50 per cent of the surveys sent were returned. Of those returned 84 per cent were grain producers but only 33 per cent of those were canola growers. Of the canola growers 37 per cent indicated that they would grow canola genetically modified for herbicide resistance given their current level of knowledge. Their intention to plant GM canola was based on their expectation about the price premium for non-GM canola, their education level, and their attitude toward the profitability of GM canola, the requirement for greater research into GM canola and GM canola as a threat to export markets.

The total cost of handling, transport and storage for all GM and non-GM canola post-farm gate to Albany Port without segregation was found to be $59.9 million. The cost effectiveness analysis of a GM canola segregated receival system indicates that the additional costs due to the dedicated system would be $2.9 million, the shared system $5.5 million and the Albany system $2.7 million. The dedicated system is more expensive than the Albany segregation system due to the increased costs to the entire supply chain of GM canola segregation at two receival points. This system inconveniences growers less than the Albany scenario and is less disruptive for the supply chain than the shared scenario and this is reflected in the cost of $2.9 million, a 5 per cent or $1.42/tonne increase on total cost. The costs to the supply chain of the shared system are high due to GM canola segregation at all receival points, while the grower is not inconvenienced at all. While the shared receival system would inconvenience growers less, it would disturb the supply chain more, and increases cost by 9 per cent, or $2.70/t, to $65.4 million. The Albany scenario carries greater opportunity costs associated with indirect delivery for growers, however, the costs borne by the supply chain are minimal. This receival system increases cost by 5 per cent, or $1.34/t, to $62.6 million.

Table 2 displays the total costs of segregation by the dedicated, shared and Albany receival systems for the final year, when production and costs have stabilised and costs are for maintenance of the system. The dedicated system has the lowest final year cost, then the Albany system, while the shared system is the most expensive. The cost break down illustrates that the Albany and dedicated systems incurred the greatest proportion of costs due to transport to port costs, while the shared system incurs the greatest cost at the receival point.

**Table 2. Present value costs incurred in 10th year of model, representing maintenance costs.**

| Cost | Dedicated | Shared | Albany |
|---|---|---|---|
| Transport to receival point | $ 61,981 | $ 61,981 | $ 61,981 |
| At the receival point | 156,817 | 609,470 | 120,817 |
| Prior to transport to port | - | 43,279 | - |
| Consequences of contamination | - | 0 | - |
| Transport to port | 175,069 | 14,060 | 214,447 |
| At port | 8,108 | 7,297 | 8,108 |
| Total cost incurred | $ 401,974 | $ 736,087 | $ 405,353 |

Sensitivity analysis conducted indicated the three scenarios are sensitive to changes in the number of growers planting canola, and the area of canola they plant. The dedicated and Albany scenarios are also sensitive to changes the factor included to account for the overestimation of grower inconvenience due to altered delivery. The shared system is sensitive to changes in the price premium available for non-GM canola. The sensitivity of the three scenarios investigated indicates that although the models are particularly sensitive to changes in some variables, it is overall robust as the ranking of the three scenarios does not alter.

## 6. Conclusion

The increase in the cost of transport, handling and storage due to segregating GM and non-GM canola in the Great Southern Region of WA, from farm-gate to Albany Port was found to be 5 to 9 per cent. Hence the results found by this study are consistent with the literature and in particular with Golder (2000) who stated that the cost of segregating GM canola post farm gate to port in Canada increases farm-gate costs by 10 to 11 per cent. The lower cost of segregation by the dedicated and Albany receival systems, only a 5 per cent increase, may be due to underestimation of the inconvenience to growers by altered delivery, as demonstrated by the sensitivity analysis. This slight difference may be due to the differences between the Australian and Canadian supply chain, the Canadian receival system places more emphasis on on-farm storage and has a wider variety of transport methods.

If the canola industry is to implement GM canola segregation following the commercial release of GM canola the Albany scenario is recommended based on cost. The Albany scenario would be most attractive to the supply chain from a cost perspective, but growers may initially feel the cost of the inconvenience they bear is not fully realised. If a shared system is introduced however, the increased costs to the post-grower supply chain will be borne by the entire supply chain and as such the grower will pay directly for segregation, rather than indirectly through inconvenience.

The main limitations of this study focus on the information available from the supply chain and the assumptions underlying the cost effectiveness model. Farmers, trucking contractors and CBH are businesses and as such certain information is commercially sensitive and was unavailable for this study. The model assumes growers can provide non-GM canola of the required tolerance level. This may not be possible in light of work completed by the University of New England (2003) regarding volunteer canola and cross contamination in Tasmania. The model also assumes all non-GM canola is delivered as non-GM canola, rather than allowing for the possibility of some being delivered as GM canola as would be possible.

Furthermore, research into the concept of grower inconvenience and its importance to decision making would be very beneficial for improving this study. By identifying how the supply chain, consumers or policy makers quantify grower inconvenience this study could more accurately measure this opportunity cost. Also, this study could be further utilised by being built upon or redeveloped for other regions of Australia, to incorporate the entire Western Australian canola production region or investigate other crops requiring segregation.

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