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The Australian Canola Value Chain

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Abstract

Canola provides significant economic value to the Australian economy, as canola is the fourth largest crop grown in Australia and Australia is the second largest canola exporter. In this study the major functions, major operators and major supporters of the Australian canola value chain are identified and analysed via value chain mapping. The performance of the chain is assessed to draw comparisons with the chain's major competitor, Canada. The results of the analysis suggest that transportation is the most important driver of performance in the Australian canola value chain, and the chain has better performance than Canada in terms of efficiency due to lower costs, higher prices, and profits. The Australian chain and Canadian chain have similar performance in terms of responsiveness, flexibility and food quality. The major challenges faced by the Australian canola value chain are the high concentration of exports to the European Union, recovering international competition, falling prices, and increased costs for inputs. Three suggestions are made for improvement - government policy alignment, adoption of remote sensing technology and development of seeds with strong abiotic resistance. It is argued that these interventions would help improve the Australian canola value chain's efficiency and competitiveness.

Keywords: canola, value chain, performance analysis, bio-fuel

Introduction

Oilseed rape is commonly used globally to produce both dietary and industrial oils, and to produce meals for animal feed. Oilseed rape is the second largest oil crop in the world by volume with 72.3 million tonnes supplied in 2022 (USDA, 2022).

The term "Canola" is registered by the Canadian Canola Association as a trademark that refers to cultivars belonging to the Brassicaceae family that can produce canola oils with less than 2 per cent erucic acid and canola meals with less than 30μmol/g of aliphatic glucosinolate (Raymer, 2002). Canola is predominantly made up of cultivars from two species, *Brassica napus* and *Brassica rapa*, and canola dominates the global markets for dietary rapeseed oil and meals (GRDC, 2018a). Most of the rapeseed produced in Australia are canola.

The Australian canola value chain provides significant value to the Australian economy. In 2019-2020, nearly 2.3 million tonnes of canola was produced in Australia, making it the sixth most produced agricultural commodity, and the fourth most produced crop by volume in Australia, only behind wheat, sugarcane and barley (FAO, 2020). The Australian canola value chain supports more than 4,500 enterprises (ABS, 2020) and provides more than US$2.1 billion in export revenue for the Australian economy (Trade Map, 2022c). Also, canola can act as a break crop in wheat rotations, which helps boost the yields of wheat and reduces pressure from pathogens (Angus et al., 2015). In 2021-2022, production of canola more than doubled to 4.8 million tonnes (ABS, 2022). Australia exported 3.4 million tonnes of canola and became the world's second largest exporter of canola in financial year 2021, only behind Canada (Trade Map, 2022c). These data highlight the importance of export trading to the Australian canola value chain, as more than 70 per cent of canola produced is exported. Coupled with increased global canola prices caused by short-term decreases in global supply, the Australian canola value chain benefited substantially.

Global canola demand is forecast to increase in the future due to increased demand for biofuel (Banse et al., 2011), and for food, edible oil and animal feeds (FAO, 2017). In recent years, the demand of canola has been growing mostly due to the promotion of biofuel via the European Union (EU) Renewable Energy Directive (Banse et al., 2011) and consumer's increased awareness and demand for healthier dietary oil products (Sánchez-Bravo et al., 2021). However, the global supply of canola is to recover from the recent drought in Canada and the instability in Ukraine which resulted in a decrease in global supply of canola in 2021-2022. The expectation is that canola prices will fall and competition for Australian canola will increase (Qin, 2022). It is important to maintain the recent industry momentum and capitalise on this opportunity to sustain the growth for the Australian canola value chain and create more values and benefits to the Australian economy. As the chain grows and expands in size, it is often more challenging for chain actors to coordinate efficiently due to diseconomies of scale (Song et al., 2021). A value chain analysis can assist in outlining potential bottlenecks to coordination.

Value chain mapping can assist identify business functions, function operators, the supporting functions and operators, and the linkages between them in the flow of material (Bonney, 2012). A value chain map of Australian canola includes all relevant functions such as inputs, production, transportation, handling, marketing, shipping, processing, and consumption. It also includes the flow of material, information, and funds.

A demand-side perspective on supply chain management tends to be more valuable in creating advantages for the value chain (Priem & Swink, 2012), as an increase in demand often leads to an increase in both the price and quantity produced, whereas an increase in supply often leads to an increase in quantity produced but a decrease in price. Therefore, in this study an analysis on the demand side of the Australian canola value chain is proritised.

Four specific objectives are proposed:

- Create a detailed map of the Australian canola value chain that can identify the various functions, operators, supporting actors and the linkages between them.
- Analyse the flows, drivers, challenges, and opportunities of the chain.
- Conduct a performance analysis for the chain using a model developed by Aramyan et al., (2007).
- Synthesise information based on the result of analyses and recommend actions for improving performance of the chain and increasing its capabilities in coping with negative impacts arising from the performance analysis or capturing future growth opportunities.

The characteristics of the Australian canola market and the factors affecting its demand are discussed first. After that, the principles and framework of value chain mapping and performance analysis are described before the results of the mapping and performance analysis are reported. The performance is then compared with the chain's largest competitor – the Canadian canola value chain. The results can then be used to highlight strengths, weaknesses, challenges, opportunities, and potential areas for improvements in the chain.

Overview of the Australian Canola Value Chain

Value chains of agricultural and food products in Australia tend to have a larger quantity of small and medium size enterprises as upstream suppliers with relatively low bargaining power and a small number of large corporate downstream processors and buyers. This is the result of more than four decades of macro-economic changes including trade liberalisation, globalisation and pro-corporate deregulation (Bonney, 2012). The Australian canola value chain includes a wide range of functions and operators. The chain includes, for example, producers of seeds for input provision, farmers for growing the crop, bulk handlers for transportation and handling, exporters for marketing and oversea sales, and crushers for processing and distribution to end users (Australian Government, 2003). Each function and its actors should be analysed and assessed to evaluate the performance of the value chain.

Trade relationship of Australian canola

More than 70 per cent of canola produced in Australia is exported (FAO, 2020). However, during drought years such as 2018 and 2019 (Bureau of Meteorology, 2022), the percentages of exported canola were lower, as overall production was lower. Domestic consumption takes precedence, and only the surplus is exported. Nevertheless, export trading remains important to the Australian canola value chain as more than half of the overall production is exported even in drought years (ABARES, 2019).

Table 1. Top-ten export destinations for Australian canola in 2021

Importers	*Volume (tonnes)*	*Share in Australia's exports (%)*
Germany	563281	25.5
Belgium	480047	21.7
France	227036	10.3
Japan	159165	7.2
Netherlands	132796	6
Nepal	112327	5.1
Bangladesh	110645	5
United Arab Emirates	83694	3.8
Pakistan	79404	3.6
United Kingdom	75786	3.4

Source: (Trade Map, 2022c)

In Table 1 the top-ten export destinations for Australian canola in 2021 are shown. Four out of the top five destinations are part of the EU, including Netherlands, France, Belgium, and Germany. These four countries account for almost two-thirds of Australian canola exports. Overall, the EU 28 imported 73.3 per cent of Australian canola in 2021 (Trade Map, 2022e). As a result, it is important to analyse the EU trade policies and regulations so as to improve the chain's performance and capabilities in dealing with any potential changes, as these can have significant impact on the Australian canola value chain (Hussey & Tidemann, 2017). Additionally, nearly half of Australian canola is exported to just Germany and Belgium. This suggests that the value chain could be highly exposed to changes in canola crushing capacity and the economy in these two countries.

Factors affecting demand for Australian canola

Increased demand for food

FAO (2017) predicts the population of the world will reach 10 billion by 2050. In order to satisfy the needs of the growing population, demand for food and agricultural products is expected to increase by 50 per cent compared to 2013, which would require an increase in production of various food products. Canola meal is a nutritious source of feed for pigs (Mejicanos et al., 2016), dairy cows (Huhtanen et al., 2011), and poultry (Khajali & Slominski, 2012). As a result, the increase in production in those food sources can lead to an increase in demand for canola, as the need for feed increases. Additionally, canola meals used as protein supplement for dairy cows can increase the yields of dairy milk (Huhtanen et al., 2011). Therefore, Australian canola can help improve the productivity of intensive livestock industries, especially for trade partners in Europe and Asia.

Similarly, dietary oils are essential to most modern diets in many parts of the world (Bester et al., 2010). A number of edible oils, such as canola oil, soybean oil, sunflower oil and palm oil are used in cooking in Asia (Lakshmipriya et al., 2013; Mishra & Manchanda, 2012). As the population grows and demand for food increases, the demand for dietary canola oil will likely increase as well.

Increased consumer awareness of healthy diets

Dietary canola oil provides numerous health benefits to consumers. Lin et al. (2013) illustrates that diets based on canola oil can help increase insulin sensitivity, increase Vitamin E levels, reduce the levels of blood cholesterol, and lower the risk of coronary heart diseases in comparison to diets involving other dietary oils that contain more saturated fat. The health benefits of dietary canola oil aligns with the growing consumer demand for healthier foods (Kearney, 2010), which could help increase the demand of canola oil and the demand of canola grains.

Increased consumer awareness of environmental sustainability

Consumer awareness of environmental issues and sustainability consequences caused by the production processes of products have been growing (Sánchez-Bravo et al., 2021). Until 2018, palm oil was Australia's second most consumed dietary oil. The rising awareness of the negative impacts on the planet caused by the production of palm oil led to a decrease in its demand (Biki, 2022). This was beneficial for canola oil, as canola oil is a competitor of palm oil. Any decreases in demand of a competitor should lead to an increase in the demand for canola oil. Also, most canola in Australia are produced with sustainable farming techniques and can satisfy the EU's sustainability requirements (AEGIC, 2021). The demand for high quality and sustainably produced Australia canola should increase as consumer awareness of sustainability increases.

Increased demand of biodiesel in the EU

As noted above, the EU is the largest importer of Australian canola, importing more than 73 per cent of Australia's canola exports. The EU is also a major promoter of sustainability and renewable energy. The EU Renewable Energy Directive promotes the production and consumption of renewable energy sources and hinders the production and consumption of unsustainable fossil fuels (Banse et al., 2011). Canola oil can be used to produce canola oil biodiesel, which is an environmentally friendly source of energy for diesel engines (J. Ge et al., 2017). Diesel engines using canola oil biodiesel emits lower levels of carbon monoxide and hydrocarbon (Roy et al., 2013). As a result, the increase in demand for biodiesel in the EU should lead to an increase in demand for canola oil and subsequently, canola grains.

Decreased supply of canola by competitors

Canada is the largest canola exporter in the world, exporting more than 8.3 million tonnes in 2021, and Ukraine is the world's third largest canola exporter, exporting more than 2.2 million tonnes in 2021 (Trade Map, 2022c). Both of these countries are major competitors of Australian canola exporters. Due to drought in the Canadian Prairies, production of canola fell by 38 per cent (Nickel, 2021). The reduced supply of Canadian canola led to an increase in the price of canola and encouraged canola importers such as Japan and Mexico to find other exporters, which presented a prime opportunity for Australian canola. Similarly, the current war in Ukraine has jeopardised Ukraine's production of canola. Production of canola in Ukraine is forecast to fall by 28 per cent in 2022 (Pratt, 2021). Generally, reduction in supply of competitors can lead to increases in demand for Australian canola.

Political tensions with trade partners

Although many of the factors affecting the demand of Australian canola are positive, the Australian canola value chain still encounters challenges and setbacks caused by international political tensions. Canola with a value of US$ 208.5 million was exported from Australia to China in 2020, which accounted for 26 per cent of the total export value of Australian canola in that year (Trade Map, 2022b). The export value of canola to China had more than doubled from US$101.2 million in 2019, so the canola trade with China had strong momentum and growth. However, China restricted canola imports from Australia in 2021 due to political tensions (Zhou & Laurenceson, 2021). This caused a significant short-term decrease in demand for Australian canola. Eventually, Australian canola was diverted to the EU and Japan, who are now the largest importers of Australian canola. The value of Japan's canola imports from Australia increased drastically from US$27.4 million in 2020 to US$157.3 million in 2021, and its share of Australia's canola exports increased from 3.5 to 7.3 per cent. Similarly, the value of the EU's canola imports from Australia increased from US$522.4 million in 2020 to US$1.58 billion in 2021, with its share of Australia's canola exports increasing from 66.4 to 73.3 per cent (Trade Map, 2022d). This highlights the importance of having adequate flexibility and responsiveness in the value chain to deal with drastic changes in demand.

Methods of Value Chain Analysis

Framework for value chain mapping

Value chain mapping is an essential component of value chain analysis (Frederick, 2019). Value chain mapping involves illustrating a visual representation of the value chain. A value chain map should identify business functions, chain operators, chain supporters and the linkages between functions, operators and supporters. The flow of product of the value chain is also identified and analysed with the goal to deliver the demanded type, quality and volume of product to maximise value of consumers. Activities in the chain are assessed and classified as either value adding, wasteful, or necessary but minimally value-adding. The flow of product should be mapped from one end of the chain to the other. This is usually from suppliers of agricultural inputs to the final consumers (Bonney, 2012). Key activities and functions in an agri-food value chain typically include provision of agricultural inputs, on-farm activities, transportation from farm to processors or handlers, marketing and sales of products and consumption.

After mapping the value chain, the flows and drivers of the chain are analysed to highlight their characteristics, importance to the chain, strengths, weaknesses, and opportunities for improvements. There are two types of drivers in a value chain. The first type is logistical drivers, which includes facilities, inventory, and transportation. The second type is cross-functional drivers, which includes information, sourcing, and pricing. The aim of the analysis is to identify factors for maximising the scope for value-addition, minimising waste caused by unnecessary functions or by-products, and ensuring an efficient and smooth flow of product in the chain to minimise unnecessary inventory or shortages.

Framework for value chain performance analysis

The difference between supply chain performance and value chain performance should be distinguished. Supply chain performance tends to refer to financial and quantitative performance indicators, such as profit, inventory turnover, and return on investment (Chopra & Meindl, 2013a). Contrastingly, value chain performance tends to also include qualitative and non-financial performance indicators, such as sustainability requirements and appealing to consumer preferences. Aramyan et al. (2007) outlined a framework to assess the performance of agri-food value chains. Four key performance indicators are suggested in the framework – responsiveness, efficiency, flexibility and food quality. Indicators for responsiveness include lead-time, fill rate and product lateness. Indicators for efficiency include profit, cost, inventory turnover and return on investment. For flexibility, indicators include customer satisfaction, delivery flexibility and volume. Lastly, indicators for food quality include the quality and safety of the product and its production processes.

Direction for improving value chain performance

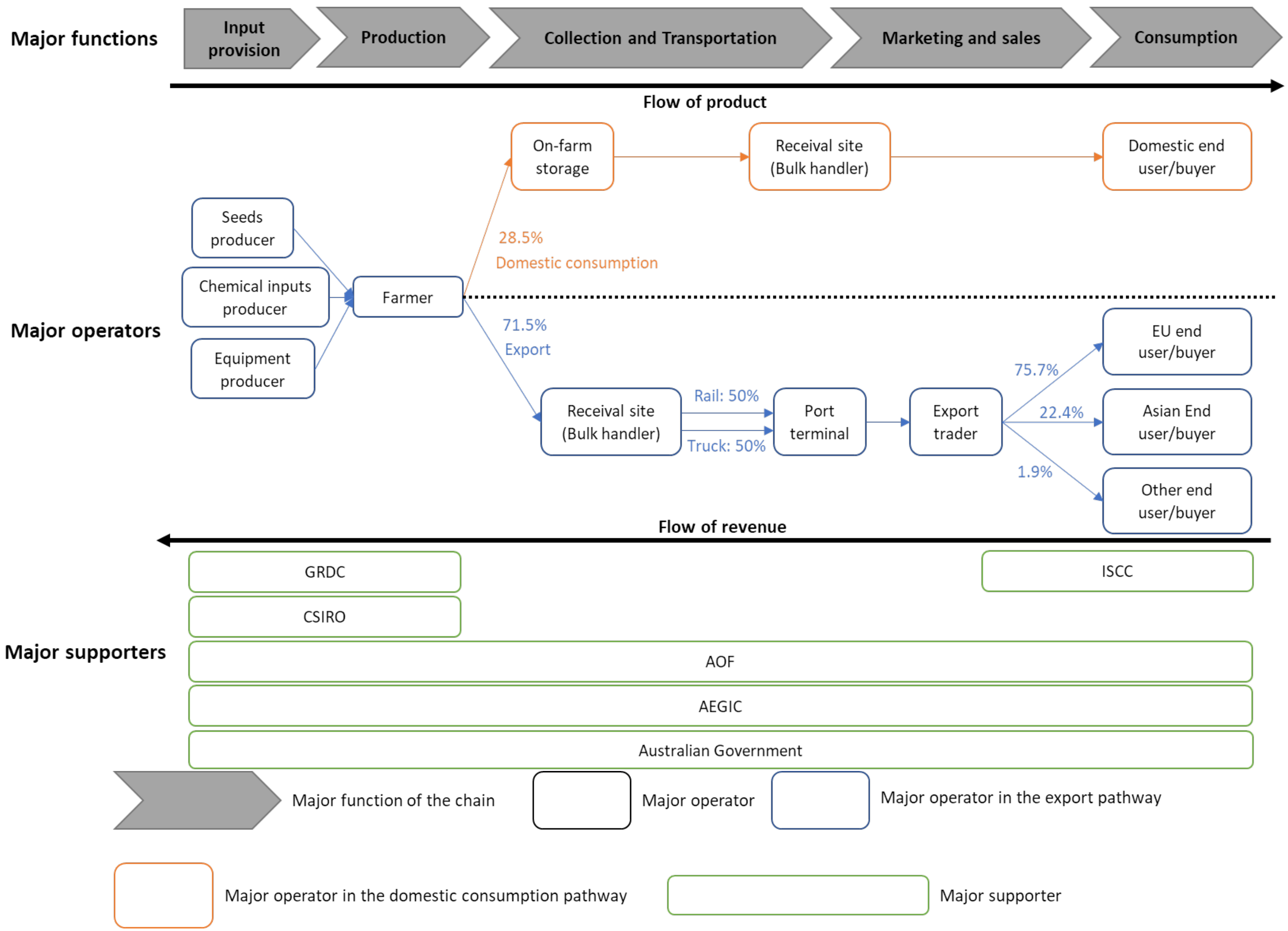
One of the methods of improving value chain performance is through improvements of value chain coordination. Improving value chain coordination can help increase sales, reduce lead-time and waste (Fisher et al., 2000). Also, value chain coordination enables stakeholders in the chain to cooperate and become a 'collective invisible hand' to rectify certain chain failures (Griffith et al., 2015). There are four major methods for supply chain coordination improvements, which include joint decision making, information sharing, advancement in information technologies, and supply chain contracts (Arshinder et al., 2008). The presence of a dominant firm in the value chain can increase the degree of coordination in the value chain, as the dominant firm can often influence or coerce other operators in the chain into cooperation with its strong bargaining power (Cheng, 2018). This is applicable to the canola value chain in Australia, as the chain contains a few large corporations downstream such as the receival site handlers and international export traders. Effective value chain coordination can facilitate a strategic fit with an intercompany scope, which enables companies at different function stages in the chain to align their competitive and supply chain strategies in attempts to maximise chain surplus (Chopra & Meindl, 2013b).

The source of statistics, data and information for this study includes government reports, data and statistics provided by reputable institutions, and academic journal articles. Sources of academic journal articles include Scopus (Elsevier), Google Scholar, EBSCO, CAB Abstract and Web of Science. Source of data and statistics include the Australian Bureau of Statistics (ABS), ABARES, Trade Map, CSIRO, GRDC and FAO. Data, reports, and literatures published in the past 10 years are prioritised.

Map of the Australian Canola Value Chain

A map of the Australian canola value chain is shown in Figure 1. The map shows the key major functions, major operators, major supporters, flow of product and flow of revenue. The map highlights the two major pathways in the chain – export and domestic consumption. Using 2021-22 data, 71.5 per cent of canola production goes to the export pathway, while 28.5 per cent goes to the domestic consumption pathway. Therefore, resources should be prioritised to improve export performance of the chain. For the export pathway, more than 75 per cent is shipped to the EU and more than 22 per cent is shipped to Asia.

Figure 1. Map of the Australian canola value chain. ***Source*****: (Carter et al., 2015; Trade Map, 2022e)**



Additionally, the export value of Australian canola to Asian countries such as Japan, Nepal, Bangladesh and Pakistan has been on the rise. The export value of Australian canola to Asia increased steadily from US$180 million in 2019, to US$260 million in 2020, and to US$541 million in 2021 (Trade Map, 2022a). Hence, opportunities are available for diversification to increase the share of exports to Asia, which could help reduce risk exposure to changes in the EU.

Major functions of the value chain

In order to facilitate and improve chain coordination and performance, major functions, operators and activities of the chain need to be identified and analysed. The Australian canola value chain has five major functions – input provision, production, collection and transportation, marketing and sales, and consumption. Input provision includes the supply of chemical inputs, seeds and production equipment. Production includes on-farm activities such as land preparation, growing, and harvesting. For the export pathway, collection and transportation include transporting canola grains from farm to receival site. Bulk handlers then sort, grade and store the grains. The grains are then transported to the ports and received by the export traders. International export traders are then responsible for marketing the products, preparing the products for sales, and shipping the products to buyers, which tend to be crushing processors. The canola is then finally crushed and consumed in the consumption stage to produce oil or meals. For domestic consumption, the major differences are that canola grains can be stored on-farm and transportation to ports are unnecessary.

Major operators of the value chain

As shown in Figure 1, different functions involve different operators. In Table 2 the major functions, activities, operator groups and examples of operator businesses in the Australian canola value chain are outlined.

Table 2. Mapping by functions and operators

Functions	Activity	Operator	Example
Input provision	Supply seeds	Seed producer	Nuseed
	Supply chemical inputs	Chemical input producer	Yara
	Supply equipment	Equipment producer	John Deere
Production	Land preparation, growing, harvesting	Farmer	Small-scale farmers
Collection and transportation	Collection and transport to receival sites	Transportation company	Contracted truck drivers
	Handling and elevation	Bulk handler	Viterra
	Upcountry storage	Bulk handler	Viterra
	Transport to port	Bulk handler	Viterra
	Receival at port	Port	Port Kembla
Marketing and sales	Market the canola for sales	Export trader	Cargill
	Shipping overseas	Export trader	Cargill
Consumption	Crushing	Crushing processor	MSM Milling

Source: (Graham et al., 2019)

Operators involved in input provision are suppliers of chemical input, seeds and equipment. The main operators for production and on-farm activities are the farmers. Operators in collection and transportation include contract transporters and bulk handlers. Bulk handlers often own and manage the receival sites and dominate a particular region in Australia. For instance, Western Australia is dominated by CBH Group, South Australia is dominated by Viterra, while GrainCorp dominates in New

South Wales and Victoria (Graham et al., 2019). For the export pathway, ports are also major operators in the chain, as exporting canola has to go through ports for overseas shipping. Examples of major ports are Port Kembla for the east coast and Kwinana for the west coast. Export marketing and sales involves large multinational corporations such as Bunge, ADM and Cargill. Contrastingly, the bulk handlers often are involved in the marketing and sales for domestic consumption. Lastly, the major operator for consumption is usually crushing processors for both the export and domestic consumption pathways.

Major supporters of the value chain

There are six major supporters involved in various major functions of the value chain. In Table 3 the names of supporters, supported function and contribution of the supporter are outlined. For instance, GRDC provides research and development support for improvements to seeds quality and agronomic management practices for the functions of input provision and production. Similarly, the AOF supports all operators in the chain by providing training, education, market insights, and support for research and development. AEGIC provides market insights to develop new value-adding activities and market opportunities for all operators in the chain. The Australian government can also support the chain by establishing government policies that align with the interests of the chain. ISCC supports marketing and sales via the provision of sustainable production certification, and CSIRO supports input provision and production through the provision of scientific research and innovations.

Table 3. Mapping by supporters

Supporter	Function supported	Contribution
GRDC	Input provision	Improvement to seeds quality and agronomic management practices
	Production	
CSIRO	Input provision	Provision of scientific research and innovations
	Production	
ISCC	Marketing and sales	Provision of sustainability certification
	Consumption	
AOF	Whole Chain	Provision of training, education, market insights, research and development
AEGIC	Whole Chain	Provision of market insights and development of new value-adding activities
Australian Government	Whole Chain	Policy alignment

Source: (Australian Trade and Investment Commission, 2017)

Mapping by cost-added

In Table 4 the values of cost-adding activities from farm-gate to export shipment in the Australian canola value chain are illustrated. This map of cost-adding is an estimation based on the cost breakdown of the Australian canola supply chain outlined by Carter et al. (2015). Since the data was collected in 2013, the values are adjusted for inflation by 15 per cent from 2013 to 2021 (Webster, 2022). The top four activities for cost-adding are transport from upcountry storage or receival site to port accounting for 25.3 per cent of the value chain cost, transport from port to export destination accounting for 21.1 per cent, handling at the receival sites accounting for 13.1 per cent, and handling at port accounting for 12.3 per cent.

Table 4. Mapping by cost-added in 2021

Activity	(AU$/t)	Share of value chain added cost (%)	Share of total cost (%)
Farm gate value (including seeds, chemical inputs, labour, fuel, maintenance and insurance)	***176.9***	***N/A***	***58.8***
On-farm storage	5.6	4.5	1.9
Cartage - farm to site	10.0	8.1	3.3
Handling and elevation	16.2	13.1	5.4
Upcountry storage	4.4	3.6	1.5
Transport - upcountry to port	31.3	25.3	10.4
Receival and handling charges at port	15.2	12.3	5.1
Other port and vessel charges	8.4	6.8	2.8
Levies and check-offs	3.2	2.6	1.1
End point royalties	3.4	2.7	1.1
Transport - port to export destination	26.2	21.1	8.7
Supply chain added cost	***123.9***	***100.0***	***41.2***
Total cost	**300.8**		**100**

Source: (Carter et al., 2015)

Analysis of Flows of Product, Information, and Funds

Flow of product

Product flows from producers to consumers. In the export pathway, product flows from producers, which range from a relatively larger number of small and medium enterprises to large-scale corporate producers, to the receival sites of a small number of bulk handlers that tend to be large corporations such as GrainCorp. Bulk handlers then add value by handling, elevating, storing, packing and transporting to ports for exports (Carter et al., 2015). The canola grains are then delivered to the export traders at ports for the export pathway or delivered to the domestic processors for domestic consumption. International commodity traders like Cargill then add value by marketing the canola for export sales and delivering the product to consumers. Three quarters is delivered to the EU and around 22 per cent is delivered to Asia (Trade Map, 2022e).

Flow of funds

Funds flow in the opposite direction of the product, from consumers to producers. In the short term funds can also start from, for instance, the bulk handlers and flow to the farmers when the bulk handlers purchase the canola grains from the farmers without onward sales contracts.

Also, there are costs associated with the certification from ISCC. In Table 5 the one-off certification fee for users with different levels of turnover is shown. Australian canola typically attracts a price premium of AU$20-40/t in the EU due to its characteristics of non-GM and sustainable production systems (GRDC, 2018b). The price premium in the EU more than covers the costs of obtaining an ISCC certificate for operators in the Australian canola value chain.

Table 5. Fees for ISCC certification

	Classification (turnover million €)	Fee (€)
Certification fee	< 3 / year	200
	< 60 / year	500
	< 150 / year	700
	< 500 / year	1000
	> 500 / year	2000
Quantity-dependent fee		0.01/t

Source: (ISCC, 2022)

Flow of information

Information flows in both directions in the chain. Information such as customer requirements and demand forecasts flow in the same direction as flow of funds, from consumers back to producers. Conversely necessary information for sales of product flow in the same direction as flow of product. Such information includes product quality, price and delivery schedules. Flow of funds and flow of information are both important in the value chain, as both funds and information allow producers to meet consumer demands effectively. Therefore, value chain efficiency and responsiveness can be improved by integrating the flow of funds and information by reducing lead time and improving order tracking (Chopra & Meindl, 2013b).

Analysis of Logistical Drivers

Facilities

Facilities are the actual physical locations for storage, assembly and fabrication of products (Chopra & Meindl, 2013a). Facilities play a major role in the Australian canola value chain, as both storage and handling facilities can have significant impacts on the chain's efficiency and responsiveness. Increasing the capacity of processing facilities can increase the throughput rate of the chain, which can help reduce lead time. Similarly, demurrage can be reduced by improvements of storage and loading facilities (Carter et al., 2015). Improving facilities of the chain can reduce lead time, storage time, processing time, loss of quality due to perishability (Singh, 2015).

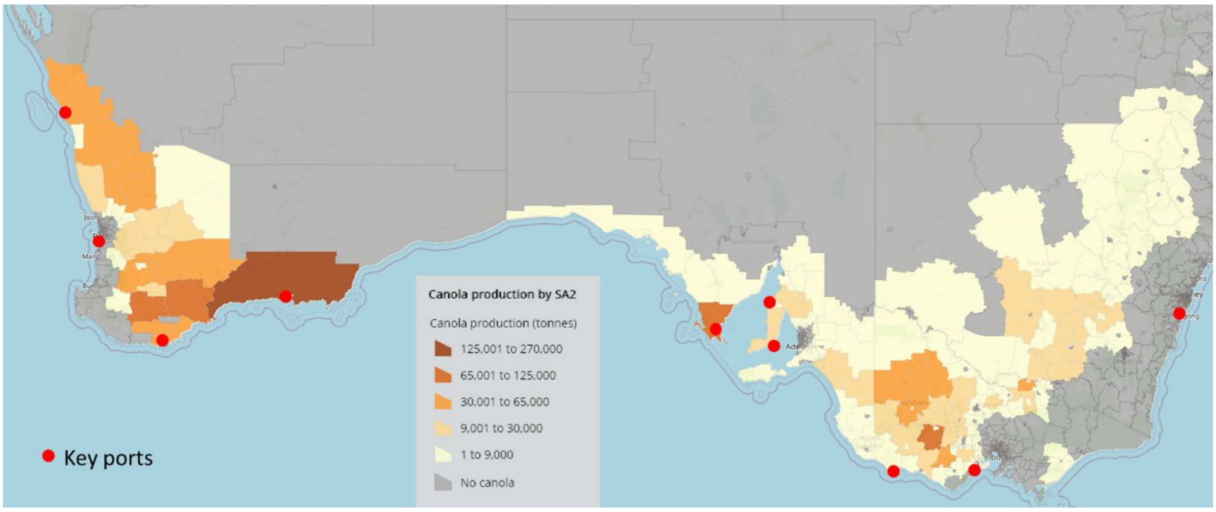
Inventory

Inventory includes all raw material, work in process, and finished products (Chopra & Meindl, 2013a). Unnecessary inventory negatively affects the chain's performance. The quality of canola tends to worsen over time due to perishability, and the cost of storage increases over time. Therefore, inventory tends to reduce chain surplus (Yang & Tseng, 2015). Precise inventory management can be used to minimise carrying inventory and improve efficiency.

Transportation

Transportation refers to the physical movement of inventory from point to point in the chain (Chopra & Meindl, 2013a). Transportation is the most significant driver affecting the chain's efficiency and responsiveness, as transportation is required in between every major function – to move canola grain from farm to receival sites, from receival sites to ports, and from ports to international buyers and consumers. Most of Australia's canola production takes place near a port (Graham et al., 2019), which is advantageous for the chain's efficiency, as it reduces the distance of transportation (Figure 2). The Australian canola chain employs a network transportation structure, as product delivery is aggregated and distributed through a port, which acts as a distribution centre with storage. Aggregation at the distribution centre helps reduce the cost of transportation but has disadvantages such as increased inventory and handling costs at the distribution centre and lower responsiveness (Chopra & Meindl, 2013c). The Australian canola value chain enjoys lower cost of transportation than its Canadian competitors (Carter et al., 2015).

Figure 2. Map of Australian canola production regions



Source: (Adapted from ABS (2020))

Analysis of Cross-functional Drivers

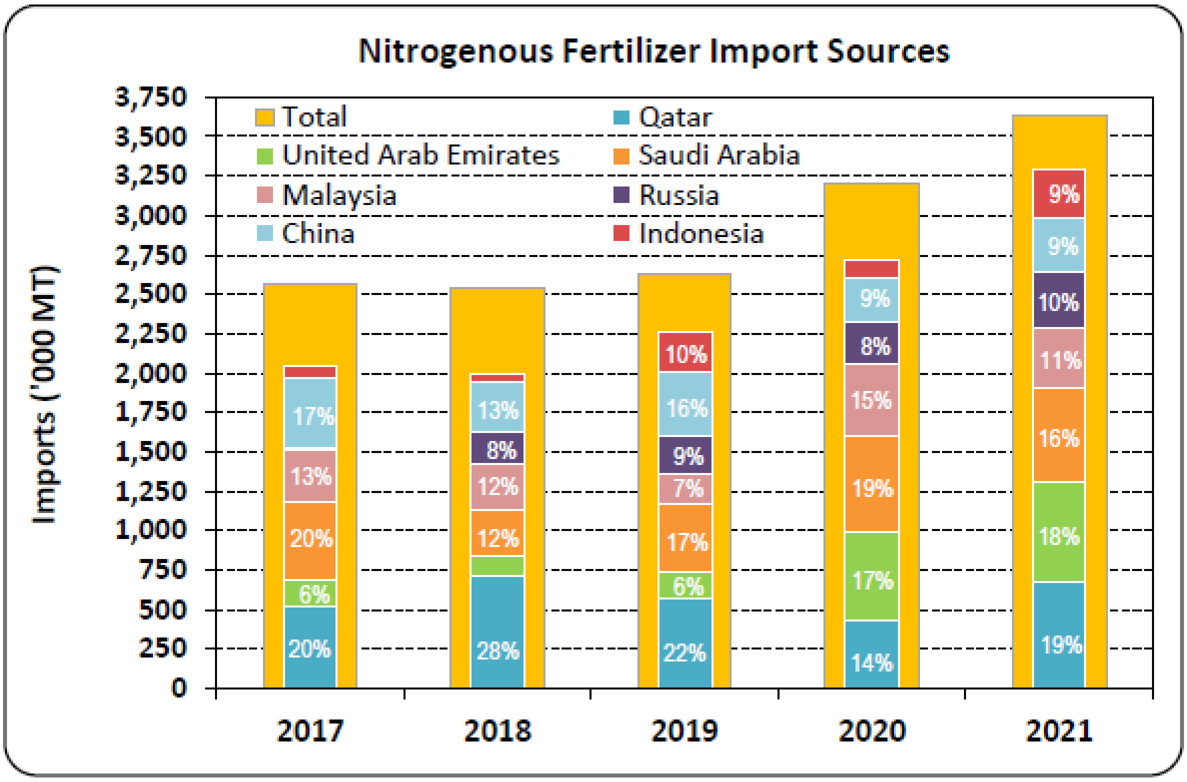
Information

Information and data sharing between operators in the Australian canola value chain can improve responsiveness, flexibility and profitability of the chain, as operators are spatially distant and global in nature. For example, Viterra shares information about their handling sites, cash pricing and delivery information with canola producers to reduce time of delivery (Viterra, 2022). Additionally, increases in chain coordination and integration can help improve information sharing (Chopra & Meindl, 2013a).

Sourcing

Sourcing involves the required business processes to procure goods and services (Chopra & Meindl, 2013a). The seeds for the Australian canola value chain are mostly sourced domestically, from companies such as Nuseed and Pioneer Seeds. Nitrogenous chemical inputs are imported from a variety of countries from the Middle-East or Asia, such as Qatar, UAE and Saudi Arabia, Malaysia, Russia, China and Indonesia. The import sources of nitrogenous fertiliser of Australia are shown in Figure 3. Australia imported more than 3.5 million tonnes of nitrogen fertilisers in 2021, and 53 per cent is sourced from the Middle-Eastern area. The price of nitrogen fertiliser has increased by 54 per cent from US$235/t in 2020 to US$362/t in 2021. The price is expected to increase even further, and reached US$654/t in January 2022. The increase in price is attributed to the increase in energy cost and supply restriction from China (Biki, 2022). As fertiliser and chemicals are crucial to canola production, the increase in price of fertiliser will negatively affect the Australian canola value chain.

Figure 3. Nitrogenous fertilizer import sources of Australia



Source: (Biki, 2022)

Pricing

As canola seed is essentially a commodity, operators in the chain are most likely price-takers and would have limited ability in setting prices (Drabik et al., 2014). The price of canola is determined by global market demand and supply. However, the International Sustainability and Carbon Certification can certify the quality and sustainability of Australian canola, which can help Australian operators gain better purchasing prices from the EU (Biden et al., 2018).

Performance Analysis of the Australian Canola Value Chain

Efficiency criteria

Costs

The costs incurred in the Australian canola value chain production were estimated and outlined in Table 4. The total cost was estimated to be AU$300.3/t for financial year 2020-2021. The cost performance of the Australian canola chain is better than its Canadian counterpart, as costs of transport from farm to receival site, and from receival site to ports in Australia are lower than in Canada. The costs of transport from farm to receival site and from receival site to ports in Australia are AU$10.0/t and AU$31.3/t, respectively (Carter et al., 2015), whereas the costs of transport from farm to receival site and from receival site to ports in Canada are estimated to be AU$13.6/t and AU$59.4/t, respectively, based on (Webster, 2022).

Profit

The market prices of canola in 2020-2021 ranged from CA$450 to CA$1030 per tonne, which is around AU$500 to AU$1100, using an exchange rate of 1CA$ to 1.1AU$. Thus, the estimated profit ranges from AU$200 to AU$800 per tonne depending on the market price. The average price of canola exported from Australia was US$631/t, compared to US$609/t for canola exported from Canada. With higher market prices and lower costs, the Australian canola value chain outperformed the Canadian competitors in terms of per unit profit.

Responsiveness criteria

Lead time

The lead time is around 6 months for the chain, as canola typically takes 4-5 months after sowing to grow and be harvested. The growing time of canola is around the same in Canada, so the lead time is also similar. Although, the time to grow is similar, Australia may have an advantage in responsiveness, as it has a slightly longer growing season. The growing season of canola in Australia starts from April to June with harvests in November and December (Potter et al., n.d.). For Canada, the growing season starts from late April to early May with harvests in September and October (Canola Council of Canada, 2022). A slightly longer growing season enables the Australian canola value chain to have greater responsiveness in dealing with spikes of demand, especially during November and December, as these months are out of the growing season for Canada.

Customer complaints

The responsiveness to customer complaints is likely low, as the lead time is 6 months, which means any complaints to the quality of canola can only be dealt with in the next planting cycle. The situation is similar in Canada, as the lead time is similar.

Flexibility criteria

Mix flexibility

Mix flexibility is the ability to change product mix. It is irrelevant for the canola producers in the value chain, as canola is a commodity, which means there are pre-determined specifications for the product in the exchange, and usually only one type of product is being exchanged on the market.

However, mix flexibility can be important to the canola crushers at the end of the chain. Mix flexibility is the ability to change the variety of the products produced with minimal disruption, in a timely manner (Aramyan et al., 2007). The mix flexibility is relatively high for processors in the canola value chains, because with small configurations and adjustments, oil press machines can crush a large variety of oilseeds other than canola, such as soybean, peanut, and sunflower seeds. As a result, the processing capacity utilisation can be maintained at a high level.

Volume flexibility

Volume flexibility is the ability to profitably modify the level of volume with minimal disruption (Jack & Raturi, 2002). The volume flexibility of the Australian canola value chain is low, as the cropping area, which determines the output volume needs to be set more than six months before the delivery of canola grains. Therefore, it has limited volume flexibility in response to changes in economic conditions that happens after the sowing period. This is the same for the Canadian competitors, but the value chain in Canada should have greater volume flexibility as the production level is higher, which suggests more resources are available to be pooled to respond to changes (C. Yang et al., 2007).

For example, for market year 2020-2021, Canada produced 19 million tonnes of canola and has a crushing volume of around 10 million tonnes (Danielson, 2021), which is much higher than the production of 4.8 million tonnes and 900,000 tonnes crushing capacity in Australia (Biki, 2022).

As climate change intensifies, extreme climate events may become more frequent. Consequently, yield variability, volume uncertainty, and price volatility may continue to increase in the future. As a result, the Canadian value chain may have the advantage in dealing with future volume uncertainties due to better flexibility, and the Australian chain should improve on this aspect in preparation for future volatility.

Additionally, as canola yield is sensitive to water stress, sufficient supply of irrigation water is essential to maintain high yields (Taylor et al., 1991). Canola can consume up to 20 inches (more than 50cm) of water throughout a growing season (Bauder, 2022). During droughts, the availability of irrigation water may be limited, and the cost of irrigation water would likely increase, which can increase the cost of production. Consequently, canola producers may reduce the use of irrigation water to offset the increase in costs, which would reduce the yields. Ultimately, droughts lead to limitations in irrigation water, which reduces the volume flexibility for both the Canadian and Australian canola value chain.

Food quality criteria

Oil content

Oil content, which is the major determinant of canola quality is within the range of 41-45 per cent for both Australia and Canada chain (Graham et al., 2019; Canadian Grain Commission, 2021).

Product safety

Product safety is high in the Australian canola value chain, as bulk handlers like GrainCorp routinely assess the received canola grains and check for seed contaminants, such as burrs, crow garlic, sesbania pea, etc and other contaminants such as snails, stones and insects (GrainCorp, 2022). Similar grading procedures exist in the Canadian counterpart (Canadian Grain Commission, 2022).

A summary of the performance analysis comparison is shown in Table 6.

Discussion

Challenges for the chain

Concentration of exports to the EU

The analysis showed that the EU imports more than 75 per cent of the exported Australian canola. Demand for vegetable oil is expected to increase, due to the recovering biodiesel consumption and stable growth in consumption of dietary canola oil. The cause of the expected increase in biodiesel fuel consumption is due to removal of travelling restrictions and the gradual global recovery from the COVID-19 pandemic (Qin, 2022). The demand for Australian canola is expected to benefit from this as the EU is a strong promoter of renewable energy and biofuel under the EU Renewable Energy Directive. However, over-reliance on demand of the EU can result in increased risks for the Australian canola value chain, as any unexpected changes in the EU's demand for canola, as occurred for China, can have a significant impact on the Australian chain.

Table 6. Summary of comparison of performance

Category	Key Performance Indicators	Comment
Efficiency	Costs	Outperforms the Canadian competitors
	Profit	
Responsiveness	Lead time	Outperforms the Canadian competitors
	Customer complaints	
Flexibility	Mix flexibility	Underperforms against the Canadian competitors
	Volume flexibility	
Food quality	Oil content	Similar performance to the Canadian competitors
	Product safety	

Increased international competition

The extended drought in Canada and the war in Ukraine has resulted in the reduction of global canola supply. This helped increase both the canola market price and the demand of Australian canola. However, as the supply from Canada is expected to recover, both the price of canola and demand for Australian canola will likely fall gradually in 2023 (Qin, 2022).

Increased cost of chemical inputs and labour

The application of nitrogenous fertilisers is important for increasing yields of canola. The price of nitrogenous fertilisers has increased substantially due to increased cost of energy and supply restrictions in China (Biki, 2022). As high levels of sulphur, nitrogen and potassium are required for canola production, the increased cost will have significant negative impacts on the supply of Australian canola, as farmers may adapt to the increased costs of input by reducing the quantity of input, which will reduce the yields (Qin, 2022). Similarly, labour is also a key input in the production of canola. It becomes increasingly difficult for canola producers to hire adequately skilled labour, as numbers in the rural workforce continue to fall (Millar & Roots, 2012). The shortage in skilled labour will lead to an increase in cost of production in the chain and constrain the chain's growth potential.

Increased volume uncertainty

As climate change intensifies, the frequency of extreme climate events will increase. Consequently, the variability in yields and the volatility in prices will increase. The Australian canola value chain benefitted from the high yields and high production level in year 2021-2022. The chain can utilise this high yield to expand their share in the global canola trading market and strengthen the relationship with existing trade partners through increased trade volume and also establish new trade partners (Trade Map, 2022d). However, if the Australian canola chain experiences a drought year and low yields in the future, there will be significant challenges in allocating the limited supply to fulfil the demands of various trading partners, and the chain will need to determine which major markets to prioritise.

Advantage of transportation

Results of the analysis have demonstrated that transportation is the most important driver of performance for this chain, as it accounts for most of the post-farmgate cost. Australia has lower costs for storage and land transport than Canada as the areas of canola production are often near ports. The distance needed for transportation in Australia is 250km in average, which is one-sixth that of around 1610km in Canada (Carter et al., 2015), providing a significant competitive advantage to the

Australian canola value chain. However, the transport cost is up to five times lower in Canada on a per kilometre basis, due to more efficient train operating standards and rail network (AgriFutures, 2019). Additionally, the Australian canola value chain aims to transport the grains as soon as possible after harvest to centralise the storage and reduce storage costs.

Another advantage of the Australian transportation network is that the grains can be transported via road or rail, which promotes competition between the road and rail transporters, which helps keep the price of transportation competitive and relatively low. In contrast, Canada's canola value chain has to rely on rail freight provided by two dominant operators, which leave canola producers vulnerable to pricing and efficiency of the dominant rail transporters (Carter et al., 2015). Although, costs of transport is lower in Australia, the quality of roads, ports, railroad and transport infrastructure is higher, and labour cost is lower, in Canada (AgriFutures, 2019). Therefore, it is important for the Australian canola value chain to improve the quality of its infrastructure while maintaining the competitiveness in costs for transportation.

Development of the Inland Rail

The Inland Rail is a major infrastructure project that can help to improve the efficiency of the Australian canola value chain. The Inland Rail will span more than 1,700 kilometres. It will upgrade 1,100km of existing rail line, while constructing 600km of new tracks to improve connection between Melbourne and Brisbane. The Inland Rail should help increase the capacity of the freight network and reduce the cost of freight transportation, which helps improve competitiveness of the Australian canola value chain, especially for the production chain on the Eastern coast (ARTC, 2022).

Suggested Improvements

Government policy alignment

Canola is the fourth largest crop grown in Australia by value, some 70 per cent is exported annually and it generates more than $2 billion in export revenue. While it has a significant impact on the agricultural economy of Australia, it is vulnerable to changes in importer requirements and policies. The Australian government as a supporter of the chain should continue to make representations to improve the market access of Australian canola and so improve the chain's efficiency and global competitiveness. For example, industry has requested the government to engage more with importing countries in Asia, such as Japan and Indonesia to build stronger networks, address existing trade barriers, and develop new relationships to improve market access, gain market intelligence, and promote Australian canola as a preferred product so as to and diversify from the EU. This initiative is estimated to cost AU$0.3 million (Grain Trade Australia, 2020). The Australian government should continue to promote and facilitate a free and level global trading environment for the Australian canola industry. Since China was a major importer of Australian canola before 2021, the Australian government could reengage with China to re-establish the trading relationships, remove the trade barriers and develop new opportunities for trade and collaborations between the grain industries of the two countries (Grain Trade Australia, 2020).

Adoption of remote sensing technology

Adoption of remote sensing technologies can help offset the increased cost of nitrogenous fertilisers and labour. Remote sensing facilitates precise application of fertilisers, as it can detect variability in nutrient requirements of a field. This improves fertiliser use efficiency (Basso et al., 2016) and allows farmers to apply a lower quantity of chemical inputs while maintaining similar yields. Also, remote sensing technologies reduces the time and resources required for manual field observation (Y. Ge et al., 2011), which reduces the demand for labour. Furthermore, remote sensing can be used to aid the processing and assessment of grains at receival sites and ports to improve throughput and efficiency.

Development of seeds with strong abiotic resistance

The analysis has shown the negative impact on Canadian canola's supply due to extreme drought. In order to minimise and reduce the potential negative impacts, the Australian canola value chain should continue to collaborate with chain supporters such as GRDC and CSIRO to develop new varieties with improved drought tolerance through advanced plant breeding.

Conclusion

This research has found that the global demand of canola is on an upward trajectory (Qin, 2022). The increased consumer awareness of healthy food products and environmental sustainability issues (Sánchez-Bravo et al., 2021) have caused the demand of canola oil to increase, which results in the increase in demand for canola, as canola oil have a number of health benefits (Lin et al., 2013) and have certification of sustainable production processes (AEGIC, 2021). Another factor for increased demand is the strong demand of biodiesel in the EU, as more than 75 per cent of Australia canola exports are shipped to the EU. Additionally, the Australian canola value chain has benefitted from the reduction in supply from competitors such as Canada and Ukraine.

There are two pathways in the Australian canola value chain, the export pathway accounts for 71.5 per cent of the Australian canola production, while the domestic consumption pathway accounts for 28.5 per cent. This indicates that the export pathway is more important, and analysis and improvements should be prioritised for the export pathway.

Transportation is the most important driver of performance in the Australian canola value chain is it makes up the majority of post-farmgate costs in the chain. The Australian canola value chain has a competitive advantage on cost of transportation over its major competitor, Canada, as the transportation distance for Australian canola is around one-sixth of that in Canada (Carter et al., 2015). The Australian canola value chain has better performance than Canada in efficiency due to lower costs, higher prices and profits, and in responsiveness. The Australian chain and Canadian chain have similar performance in terms of food quality, but Canada does better in terms of flexibility.

This research highlights that the major challenges faced by the Australian canola value chain are the concentration of export to the EU, recovering international competition, falling prices, and increased costs for chemical input and labour. This research proposes three interventions, which are government policy alignment, adoption of remote sensing technology and development of seeds with strong abiotic resistance. These interventions should help improve the efficiency and competitiveness of the Australian canola value chain, while reducing risk exposure.

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