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Prospects for Developing a Sustainable Medicinal Cannabis Industry in Australia

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Abstract

A new market for cannabis has opened for Australian cultivators due to domestic and global legislative changes. Growing cannabis for medicinal purposes requires licensing, stringent cultivation techniques, increased security and can have high set-up costs. In this paper, a critical review is undertaken of the current state of the Australian market. It is found that it is a market already dominated by large and experienced international companies; has relatively unknown supply, demand and price data (actual and forecast); and is in a state of constant change and uncertainty. The longer-term sustainability for this unique industry will require accessibility to reliable data, internationally competitive production costs, and sensible government regulation. International best practices must be used or adapted for Australian conditions to minimise environmental damage, and Australian patients must have ease of access to cannabis-derived products.

Keywords: Cannabis, medicinal cannabis, medical marijuana, legislative changes, cultivation, sustainability, pharmaceutical, cannabidiol.

Introduction

As a regulated crop, cannabis is a relatively new agricultural product globally and it is a very new market in Australia. There are several difficulties in researching and evaluating this market: there is limited independent Australian-specific research available; forecasts can be based on conjecture and are made for a market that has faced and continues to face rapid change; and the global and domestic markets are subject to legislative changes which means those operating in them are doing so in a state of uncertainty.

In this paper, the Australian market is critically reviewed, and the longer-term sustainability of the industry is assessed. Sustainability is broken down into the three aspects of economic, social, and environmental sustainability.

The Australian Market

Legislation and licensing

In February 2016, the Australian Federal Parliament passed legislation allowing for the cultivation of cannabis for medicinal and related research purposes (Office of Drug Control (ODC), 2016). The change

to the Narcotic Drugs Act 1967 (the ND Act) allows for licenses and permits to be granted for the cultivation, production, and manufacture of medicinal cannabis products (Australian Government, 2018). It is a highly regulated industry subject to oversight by both the ODC and the Therapeutic Goods Administration (TGA). Currently there are no restrictions on how many cultivator licenses the ODC will grant - they state it will be balanced with domestic demand, and domestic demand must be met before any exportation is allowed.

In Australia, patients can access these products via a Special Access Scheme (SAS) or clinical trials. Medicinal cannabis products can only be prescribed by an authorised physician, although products defined as low dose cannabidiol (CBD) oil with less than 1 per cent THC (Tetrahydrocannabinol) are technically available without prescriptions from pharmacies since February 2021. Patients are not allowed to grow their own plants or have a 'carer' grow them for them, as is allowed in many parts of the United States and Europe. The concept of 'dispensaries' as used overseas to sell medicinal cannabis to the public is not legal in Australia.

A cultivator will only be granted a licence if they meet the ODC 'fit and proper person' test which is outlined on their Medicinal Cannabis webpage (ODC, 2016) as including "consideration of the applicant's criminal history, financial viability, business history and capacity to comply with licensing requirements." A cultivator must also have a proven agreement with a licensed producer or licensed manufacturer. If the cultivator is growing for research purposes, they must be able to demonstrate the purpose of the research. Finally, before any growing can occur, the cultivator will also need a permit which will authorise the type and amount of cannabis that can be grown. The permit process requires the facility to be extremely secure (including transport vehicles that must be hijack-proof) and set up and ready to go before the permit is granted. This means funds must be invested in infrastructure before there is a guarantee of a permit. Williamson (2018) notes that as the licensing and permit process can be long and expensive, several Australian cannabis companies instead rely on either domestic partners that already hold licenses and permits, or international partners who hold licenses overseas to grow and then import the cannabis.

If a cultivator already grows industrial hemp (for food, seed, seed oil, fibre, or hurd), they must maintain strict separation of the crops and will be subject to site visits to ensure compliance. Growers of industrial hemp are not explicitly licensed to extract CBD or supply their plants to medical CBD producers as CBD falls under state poisons standards. The legality of growing hemp for CBD extraction in Australia is currently unclear. The NSW Department of Primary Industries (DPI) (2018) recommends that people looking to provide hemp for CBD extraction should seek independent legal advice.

The above information is based on Federal legislations, laws may vary between states and territories, including the requirement to apply for state poisons licenses.

The ODC no longer publishes the numbers of cultivator licenses granted unless they have been given permission by the holders to do so. As at March 2021, ODC (2021) show: 26 companies with a Medicinal Cannabis License, three companies with a Cannabis Research License, and 11 companies that hold both. The Government does not release any further information on the licensees. The companies that are widely known to hold licenses have either announced it themselves or have had to disclose it as part of Australian Stock Exchange (ASX) disclosure rules.

Claughton (2017) noted that most companies are seeking to grow in greenhouses for both security and production reasons. Cultivation locations are generally not made available; however, in June 2018 Australia's Cann Group made an ASX announcement of their agreement to build a 37,000 square-metre greenhouse facility within Melbourne's Airport Precinct (CANN Group, 2018b). It will include infrastructure to allow for cultivation, development, and production. The Cann Group say they were

issued Australia's first medicinal cannabis research license and Australia's first medicinal cannabis cultivation license. As stated on their website, they are a company focussed on "plant genetics; breeding; cultivation; extraction; analysis and production techniques to facilitate the supply of medicinal cannabis for a range of diseases and medical conditions." (CANN Group, 2018a).

The cannabis grown in Australia for medical purposes must meet standards set by the Therapeutic Goods Order No. 93 (Standard for Medicinal Cannabis). These standards are meant to ensure "that medicinal cannabis products will be manufactured to a consistent and reproducible quality." (TGA, 2017, p1). There are six separate tests that must be carried out on the cannabis plants using "macroscopic examination, microscopic examination and chromatographic procedures" (TGA, 2017, p4) in order to positively identify the plants as coming from the cannabis genus. The standards also apply to the potency of the cannabinoids and to the acceptable limits of any decontaminants that may be present due to the growing process (for example pesticide residue).

As per the ODC (2016), importers may only import from countries where cannabis is approved for medicinal use at the federal level (including seeds for cultivation). Only medicinal cannabis products or extracts may be exported; cannabis plants and cannabis resin are restricted.

Australian environment

The Australian environment is well-suited to the growing of broadacre cannabis. However, it is expected that most Australian growers of medicinal crops will opt for greenhouse conditions due to the security regulations imposed as part of licensing conditions (for example: security fencing, guards, restricted access, and plant level auditing). It is considered that all latitudes of Australia provide sufficient natural light and heat for one (possibly two, further north) growing cycles; however, water and energy requirements will be significant determinants in the method, location, and variety to be cultivated. It is possible that current pricing of water and electricity could be prohibitive to start-up cultivators.

Broadacre industrial hemp is currently grown in some areas of Australia, such as the Clarence river catchment area in New South Wales. Farming expertise will increase as trials with Australian-suited varieties and varying harvesting times are conducted.

Trade policy and price

The Australian Government and the ODC are allowing tightly controlled imports of medicinal marijuana products from countries where the exporting country's government has granted permission. The intention is that by allowing importation, Australian patients will have access to the products whilst the Australian supply and production chain is setting up. The ODC infer that after the Australian domestic scheme is able to supply the market, importation will no longer be allowed.

Cannabis seeds and genetic material can be imported for cultivation and research. The importer requires a cannabis license and permit from the ODC and an import licence and permit from Australian Customs.

As mentioned previously, products and extracts are allowed, but cannabis and cannabis resin are restricted. Exportation will be allowed if it does not affect Australian supply. The ODC do not elaborate on how this will be measured or quantified. Restricting the exportation of cannabis and resin restricts potential export value. As an example, Hikurangi Cannabis Company is a New Zealand cultivator who have signed an agreement to provide 12,000 kilograms of cannabis products (including extracts and whole flower buds) over three years to a United States company for approximately \$155 million dollars

(Scoop Independent News, 2018). This agreement was dependent upon the passing of New Zealand's Misuse of Drugs (Medicinal Cannabis) Amendment Bill. It was passed in December 2018.

The primary wholesale markets are for the psychoactive compound delta-9-tetrahydrocannabinol (THC) and CBD oils or distillates. Price will depend on the regulations on growing conditions, whether the product is THC or CBD-based, and the corresponding purity levels. For example, top price will be demanded for THC distillate that has been extracted from plants grown in Canada following the internationally recognised Current Good Manufacturing Practices (CGMP), or CBD distillate that is THC free. Lower prices will reflect products such as CBD extracted from GMO hemp plants cultivated in China (McMillian, 2018).

ABC Rural News (2017) quoted a price of \$US30,000 per kilo or litre for the purest form of medicinal oils. However, prices can be distorted as many of the large international cannabis companies are vertically integrated and can grow and extract their own oils and distillates, moving the products between divisions of the company at various costs. There is imperfect information available on supply, demand, and price. This adversely affects decision making for those involved in the industry. It is also difficult to estimate the value of a crop based on the oil or distillate price as plant variety, growing conditions, and extraction methods can all affect potency and yield.

Rhizosciences is a Seattle-based cannabis consulting, development and management company who offer some current CBD pricing information on their website (Rhizosciences, 2021). They highlight that price can be varied due to things such as quality, location, and testing standards. Contract terms are also a factor, for example discounts are possible when buying on long term contracts.

Pharmaceutical industry

The Australian Medical Association (AMA) in conjunction with the New South Wales, Victorian and Queensland governments are waiting on the completion of clinical trials before establishing clinical guidelines on the how and when medicinal cannabis may be supplied to Australian patients. The AMA want to validate international research and to validate the local product both in terms of potency and how it compares to international products. In January 2018, AMA discussed the AMA's position on medicinal cannabis via a media release (AMA, 2018). Included in the statement it was said "we're going to be guided by the evidence, and at this stage it's still working through that, and the indications are small and potentially not that expansive." This opinion is challenged by AusCann, an Australian listed cannabis company who are licensed to cultivate, produce, and manufacture medicinal cannabis. The Finance News Network (2018) quotes that AusCann estimate that "neuropathic and chronic pain... in Australia alone... is a \$9 billion opportunity." An early result of these clinical trials was the admission of the cannabis extract-based Sativex[®], an oral spray for relief of multiple sclerosis-based spasticity, onto the TGA list of approved medicines in February 2018 (nabiximols is commonly quoted with the product name and is the cannabis extract).

Since the Australian legislative changes announced in 2016 and export restrictions lifted in 2018, some cannabis and pharmaceutical companies have been raising funds to ramp up their research and manufacture capabilities. Most of the medicinal cannabis stocks listed on the ASX are not cultivators but research and development-based pharmaceuticals (Collette, 2018). Although many of these companies are spinoffs from existing overseas conglomerates or are vertically integrated Australian firms in partnership with these overseas companies, this is a new industry without a proven Australian background. Several of the listed companies are not yet making positive returns, however they have seen large stock price increases which could in part be due to speculative trading based on the perceived success of the pharmaceutical market for cannabis-derived products.

Sustainability in the Australian Market

Sustainability is important to evaluate for an industry and market in its infancy. The evaluation will provide an avenue to identify any potential positive and negative impacts, and an insight into whether this is an industry that is both suited to, and viable in, Australian economic, social, and environmental conditions.

Australian income and economic benefit

ODC (2016) indicated that they expected Australian patient demand would result in a need for between 5 and 10 tonnes of crop for the first year of Australian-supplied cannabis (at the time expected to be 2018). McMillian (2018) estimated the supply to be worth between AUD \$50 and \$100 million to the industry. It is unclear whether the economic benefit will be additional agricultural gross domestic product (GPD) or whether there will be some level of substitution, particularly in any broadacre cultivation replacing a traditional crop.

The new market provides new opportunities for income to be made by secondary companies via technology and innovation or an increase in demand for their services. For example, Roto-grow is an Australian hydroponics ASX-listed company selling innovative hydroponic systems to global leaders in the cannabis business. In March 2018, they signed a deal with a Canadian company worth \$2.3 million to supply their systems (Proactive, 2018). After analysing the post-legalisation experience of Colorado in the United States, MPG (2016, p6) discuss the “increasing demand for; warehousing, cash management, security, testing, legal services, climate engineering for indoor cultivations, cultivating infrastructure, agronomists, and employment of hand pickers.” In time, such secondary impacts can be analysed for value in the Australian setting.

Supply, demand and production costs

In its study into the Colorado marijuana market and its earlier investigation into production management, MPG (2016) highlighted several aspects that affect both the supply and demand of the legal marijuana market in Colorado. These are summarised below with other factors that can create difficulties in market size estimation and forecasting beyond the American example.

Like most markets, there are multiple factors that may affect supply and demand (MPG, 2016). Some of them follow, along with other factors that can create difficulties in estimating market dynamics and forecasting beyond the North American example.

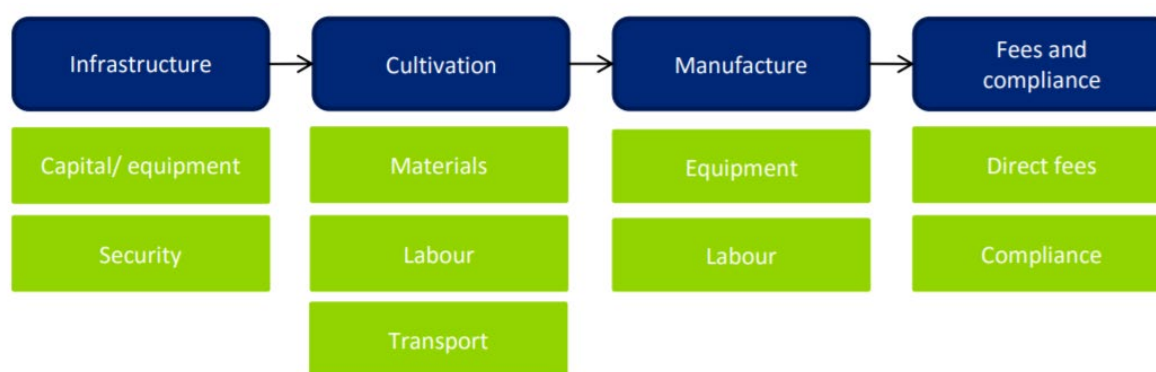
Legal regulations can impact supply via restrictions on license numbers, overall supply caps and production quotas, changes to new markets or export markets, origin of cultivation restrictions, product testing requirements, the legal status of CBD from hemp crops, and compliance costs. Demand can be affected via product restrictions, ease of access to products, and changes to regulations around for example the use of cannabis derivatives to treat animals.

There will be variation in the supply chain due to differing yields of cannabis crops with different cultivation and extraction techniques, CBD to THC ratios of different variants, the treatment of inventory buildup and any inherent flexibility in the supply chain. The competitive environment can be affected by barriers to new entrants caused by capital outlay requirements, limited resources, domain knowledge, the lag time between being granted a license and actual production, and ineffective government legislation.

The production system allows for various production methods and cycles (for example annual, semi-annual, indoor). It is an industry that has seen and has scope for improved technology across cultivation, sales, manufacturing, and testing. As research continues and there is improved awareness and acceptance, the opportunity for value added products increases.

Deloitte Access Economics (2016) provided what they referred to as a 'desktop analysis' of the costs of producing medical grade marijuana for broadacre, greenhouse, and indoor cultivations. Costs were broken down into infrastructure, cultivation, manufacturing process, and fees and compliance costs. Using a demand figure of 11 tonnes (see below) the total estimated cost range is between \$10.6 million for broadacre production (\$0.96 per gram) and \$41.8 million for indoor operations (\$3.80 per gram). The main source of costs for each stage of production are shown in Figure 1.

Figure 1. Overview of the stages of production and main cost areas



Source: Deloitte Access Economics (2016, p.15)

Cannabis Compliance Inc. (CCI) (2017) detail that the Canadian experience has shown that greenhouse cultivation can cost between \$1.50 to \$3.00 per gram (using an average of CAD:AUD of 1:1 for conversion). As yet, there has been no broadacre cultivation of medical cannabis (apart from industrial hemp) in Canada, but CCI's models show that outdoor production could cut costs by 90 per cent (equates to a range of costs of \$0.15 to \$0.30) as there are significantly lower costs required in regard to facilities, equipment, and electricity. It is estimated that 20 acres of land could produce 25,000 kg per harvest. Canada's Canopy Growth Corp expects that approximately a 23,000 square metre greenhouse should be able to produce 10,000 kilograms of marijuana annually (Sharp, 2017). As a guide to the value of medicinal cannabis yield, CCI use \$5 per gram in their modelling. For comparison, the Grains and Research Development Corporation (GRDC, 2018) released the average production costs and prices for Australian wheat for the period 2011 to 2015. They found the average price was approximately \$316 per tonne (0.000316 cents per gram). Average cost of production per tonne was approximately \$219 (0.000219 cents per gram).

It is unknown how many cultivation and manufacture licenses the ODC will grant and data on actual supply figures is limited. Some of the Australian cannabis growing companies have announced that they are 'production ready' but as yet there is no reliable data on actual production levels.

ASX-listed company MGC Pharmaceuticals released a white paper with the University of Sydney in 2016 which provided a preliminary forecast of Australian demand (MGC Pharmaceuticals, 2016). They did so based on the types of regulations likely to come into force and then how many people would most likely be eligible to use medical cannabis for their condition. The estimated number of patients and the recommended THC / CBD dosage was used to create a national annual demand. It was estimated that 30,400 Australians will demand 166.6 kg pure THC and 404.7 kg pure CBD per year

(approximately 11 tonnes of dried flower). It is noted in the paper that the estimation uses rough numbers and obtaining a more accurate demand estimate would require data that was not then (and is still not) available.

The TGA releases the number of approved applications by prescribers for unapproved medicinal cannabis products via the Special Access Scheme (SAS). To February 2021, they have approved over 99,000 applications since 1992. As at August 2018, that figure was only 1204. In July 2018 an online system was set up for applications facilitating easier access.

It is worth noting that these numbers do not include patients prescribed Sativex® and that these numbers can include multiple requests for one patient or repeat requests. There is no information regarding the number of applications received versus the number of applications approved so the data cannot be used as an indicator of overall patient demand for cannabis products. It can be used as an indicator of growth in the actual market demand for these products over time.

Export demand levels are an unknown. As above, the actual data (not forecasted data) is not yet available.

Social externalities and welfare

UNODC (2017) discusses an increase in illegal use of marijuana in states and provinces where medical use is allowed (especially where regulations allow the use of dispensaries). It is assumed that this is due to a perception of 'reduced harm' with cannabis use. Australian regulations are more restricted; Pacula et al. (2014) find that where there are patient registrations and tighter regulations, there is either no impact or a negative impact on recreational use.

A positive externality is discussed by Bachhuber et al. (2014) who found that those parts of the United States that have enacted medical marijuana laws have lower levels of opioid analgesic (used as painkillers) overdoses and over time that level continues to reduce. Medical marijuana laws also provide an opportunity for some users seeking medical relief to no longer rely on the illicit market. It may also offer an alternative to some users who do not wish to use opioid analgesics.

Health care costs

Due to legislative variations there are differences in what forms of cannabis or cannabis extract is legal, how cannabis can be procured, and what factors determine patient eligibility. This can make quantifying the impacts of medical marijuana on health care costs for Australian case study purposes difficult. Although the work does not highlight the differences in costs to individuals, Bradford et al. (2017) found that for parts of the United States with some level of medical marijuana laws, the use of prescription medication was lower than states without such laws when treating symptoms of five broad clinical areas (depression, nausea, psychosis, seizures, and pain). Whilst this indicates a positive social aspect, due to Australian laws the benefit cannot be extrapolated to Australian users as they will only have access to cannabis products via prescriptions.

UNODC (2017) summarised that there is conclusive and substantive evidence that medicinal cannabis can assist in the treatment of chronic pain, chemotherapy-induced nausea, and can improve Multiple Sclerosis (MS) spasticity symptoms. By looking at the number of Australian sufferers (including those diagnosed with epilepsy), the scale of potential healthcare savings to both the Australian Government and society may be inferred:

- Chronic pain: 1 in 5 people, increasing to 1 in 3 when over 65 years (Pain Australia, 2018);

- Chemotherapy-induced nausea: 150,000 patients each year (Department of Health, 2014);
- MS spasticity: 23,700 Australians are living with MS of which 60–80 per cent suffer from spasticity symptoms (Australian Bureau of Statistics (ABS), 2012); and
- Epilepsy: 250,000 currently, with approximately 3 to 3.5 per cent of the Australian population expected to experience epilepsy at some point in their lives (Epilepsy Action Australia, 2017).

Based on currently available information, there has not yet been great benefit to the health care costs of Australian cannabis patients. In October 2018, the TGA approved the second cannabis-derived medicine in Australia, MGC Pharma's CannEpi™ which is an orally administered treatment for forms of drug-resistant epilepsy. Up until then, the only cannabis product registered as a medicine and marketed in Australia was the anti-spasticity medication Sativex® (NSW Department of Health, 2018). The Pharmaceutical Benefits Scheme (PBS) reviewed subsidising Sativex® in 2013 (Department of Health, 2013) and rejected the submission based on (p9) "insufficient evidence to establish comparative effectiveness and safety compared with standard care alone." It was estimated the cost to the PBS would range between \$10 and \$30 million dollars for the next five years (from 2013). As the drug has not been subsidised, it can be assumed that those costs were instead paid by Australian patients; however, it may be assumed that the rate of predicted usage of the subsidised drug versus the actual rate of usage of the non-subsidised drug will have impacted the actual burden. An example of financial burden is given by McGregor (2017) who estimates that treating a child with paediatric epilepsy may cost up to \$120 a day without PBS subsidisation. McGregor estimates up to 100,000 Australians are accessing marijuana for medicinal purposes via the illicit market due to these kinds of costs and the general inaccessibility of cannabis-based medicines to the Australian public.

Environmental impacts

To date, the information released by various Australian Government departments has primarily focused on guidelines for cannabis licensing, manufacturing standards required for medical products and export, and patient accessibility via the prescription process. There has been no focus on environmental best practices specifically for cannabis cultivation. At this stage, along with TGA and GACP (Good Agricultural and Collection Practices for Medicinal Plants) standards, Australian cultivators should be referring to international examples for potential environmental impacts and best practice guidelines.

A summary of the potential environmental impacts of marijuana cultivation has been given by Ashworth and Vizuet (2017). They note in particular excessive water and energy demands, and local contamination of water, air and soil from waste products such as organic pollutants and agrochemicals. When grown outdoors, compared to other large-scale monoculture crops, Montford and Small (1999) found that it is a comparatively environmentally friendly crop, since the cultivation process requires fewer chemical inputs than other crops. Herbicides may only be required before seedlings are planted, as once the plants are established, there is too much shade for weeds to grow. Chemical fertilisers can be replaced by manure as cannabis is a nitrogen hungry crop and it thrives on the high levels of nitrogen that manure provides. When grown indoors, Mills (2012) estimates that on average, a single kilogram of processed product, is associated with 4,600 kg of carbon dioxide emissions to the atmosphere, the equivalent of the emissions created by driving a car across the United States 11 times. The calculations are based on large-scale indoor cultivation in the United States where environmental conditions are completely controlled. Mills notes that the data used in the study is referencing a combination of legal and illegal growing set-ups and the data is intrinsically uncertain due to both the proprietary and sometimes illegal nature of cultivation.

Whether the growing method is via intensive indoor, greenhouse or broadacre; there has been very little scientific research completed on the environmental impacts of cannabis cultivation. The industry

is undergoing extraordinary change and has the potential to either create further agricultural environmental damage, or become a “progressive, world-leading example of good practice and environmental stewardship” (Ashworth and Vizuete, 2017).

Indicators of Sustainability

The medicinal cannabis market is a unique market. It has an unknown future, some sectors (for example Australia) are in extreme infancy, whilst some sectors (like Canada) are more established. It is also a market that requires a balance between governmental regulatory controls and a free operating market to ensure viability, competition, and fair pricing.

To gain an understanding of the overall sustainability of a market or industry, the economic, social, and environmental sides must all be considered. Sustainability indicators can be used as a tool to identify issues or make a problem visible (Dahl, 2012). Such indicators provide market participants, potential market participants, regulatory or casual observers a platform from which to evaluate the current and future state of the industry they are interested in.

Economic indicators for the medical cannabis market could include the capital and debt levels of cannabis companies and shareholder returns, the prevalence of low-cost cultivation in emerging countries, the impact to government healthcare funding and income tax receipts, agricultural returns and the contribution to Gross Domestic Product (GDP), and any changes to the efficiency of natural resource allocations.

Social indicators could include the price and ease of availability (which includes access to imports), any substitution effects with for example prescribed opioids or any method of self-medication, impacts to individual healthcare costs, and increased employment opportunities in the primary or secondary markets.

Environmental indicators would be the usual benchmarks for an agricultural industry focused on limited resource allocation, chemical use, waste production and management, and technological innovation.

Conclusion

This study has described a cannabis market in an environment of change, where there are untested supply and demand forecast methods coupled with buoyant investor sentiment. Cultivation can have crippling set-up costs and comes with a heavy regulatory burden. It is a cultivation industry already dominated by large international institutions. Due to its infancy, there is little Australian-specific research that has not come from either invested cannabis or pharmaceutical companies, stock market research firms or media agencies. There is not enough current and verified information to understand the dynamics between demand, supply, and price. Assessing the sustainability of this market at this early stage is difficult. It is possibly easier to identify sustainability by looking for the absence or emergence of issues. To do so requires the identification of sustainability indicators that should be monitored. The discussion section has recommended economic, social, and environmental indicators that are suitable for this unique industry. Time and research are required to be able to monitor and evaluate them.

Cultivating cannabis in Australia has the potential to be sustainable if the industry can become competitive in an export market where only extracts and finished products are allowed, environmental best practices are encouraged and followed (including the use of renewable energy), and if there is both acceptance by the Australian medical profession and there is ease of access to

products for Australian patients. Expanding export licenses to include raw plant material, allowing hemp to be grown for CBD extraction, and Government legislation that keeps up with global change are three possible avenues to increase the potential sustainability of this market in Australia.

Recommendations for Further Research

The further research questions suggested here is designed to provide guidance on whether the cannabis cultivation industry can provide a sustainable opportunity for Australian farmers and the Australian value chain.

Economic research

In the future, will there be scope for Australian farmers to provide crops to manufacturers or is the industry going to remain dominated by international companies with their own international supply routes and greenhouse set-ups? This research will require visibility of actual supply and demand, and the movement of inventory between countries and companies. The capacity of current greenhouse systems will need to be tested. Does the actual output meet expectations? Will there be a shortfall in company production that may lead to contract farming opportunities?

What are the effects of recreational legalisation in Canada? Will there be a medical grade supply shortage due to higher financial returns for recreational production rather than medical grade production? Does this provide an opportunity for Australian exporters? This research will require clarity on the origin of product sold to be able to identify shifts in supply and an understanding of global export capabilities suitable for medical grade substitution.

If legislation is clarified or amended and CBD can be legally extracted from Australian grown hemp, which low-THC, high-CBD varieties are especially suited to Australian growing conditions? What are the most efficient planting and harvesting times for different latitudes of Australia? This research will require agricultural trials.

What are the current and forecasted impacts to supply by countries with low cost production? Does this make Australian producers too costly? Research into these questions will require clarity on international production methods and standards, actual supply figures, visible market pricing, an understanding of global importation legislation, and information on the Australian cost of production. It will also require an understanding of the effect on demand when GACP standards are not followed.

What impact does the change to the United States 2018 Farm Bill, where hemp and any derivatives (including CBD) with less than 0.3 per cent concentration of THC were removed from being labelled as 'marijuana' in the Controlled Substances Act (CSA), have on the global supply of CBD? Are farmers from the United States in a position to quickly increase production and can they continue to dominate the CBD market? Does this leave room for potentially more expensive Australian cannabis-derived CBD? This research will require actual figures on the demand for hemp-derived CBD, the cost of production in the United States, the cost of Australian production, visible market pricing, and an understanding of the current state of hemp farming capabilities in the United States and the ramp-up lead times for both countries.

Social research

Has the introduction of medical marijuana in Australia increased rates of smoking in children and teenagers? Has there been an association of less harm due to the acceptance of the drug as medicine? Has the introduction of medical marijuana in Australia decreased the use of alcohol and heroin for

those who have been self-medicating? This research will require both surveys and case studies to be completed over time.

Environmental research

Are growers adopting best practices and are technical innovations improving cultivation methods and reducing environmental harm? This research will require an understanding of international best practices, how they apply to Australian conditions and how cultivators are implementing them.

Finally, what are the energy and water consumption levels for Australian cultivators? How do they compare to other agricultural industries? This will require access to cannabis cultivator data and equivalent agricultural data.

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