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Access Economics

Economic activity attributable to crop protection products

CropLife Australia

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Glossary

Acronym	Full name
ABS	Australian Bureau of Statistics
APVMA	Australian Pesticides and Veterinary Medicines Authority
CPP	Crop protection products, also known as pesticides or agrichemicals, which are applied in both conventional and organic agricultural systems. Also includes chemicals such as plant growth regulators.
FTE	Full time equivalent
GDP	Gross domestic product
GOS	Gross operating surplus
USA	United States of America

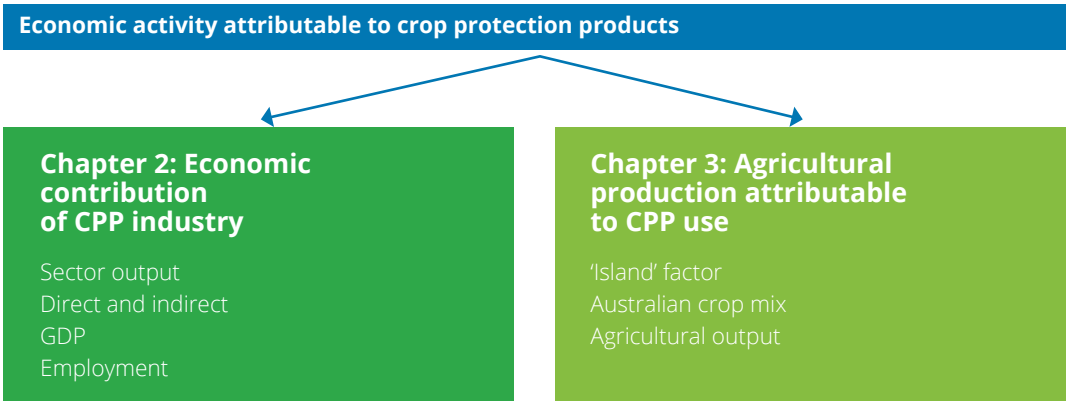
Executive summary

Deloitte Access Economics has been engaged by CropLife Australia to estimate the contribution of the crop protection industry to the Australian economy, and the Australian agricultural output attributable to the use of crop protection products (CPP). This report represents an update to a report released in 2013 by Deloitte Access Economics.

CPP include herbicides, fungicides and insecticides, which are widely used in many sectors of the economy. For industry — particularly agriculture — it is a means of increasing the productivity of land. Governments also use CPP to control invasive or non-native species on public land (such as roadsides and in national parks). They are also widely used by households for backyard gardening and pest control, in commercial buildings and maritime applications. That noted, this report focuses on the contribution of the CPP industry to value added in the Australian economy (as an employer and purchaser of inputs from other industries), and the contribution of CPP use to crop production. The value and importance of CPP to public land and other environmental land managers has not been addressed in this report.

The approach used in this study is two-fold:

- First, the direct and indirect economic contribution of the CPP industry to GDP and employment are estimated.
- Second, the share of crop production in Australia attributable to CPP is estimated. This utilises previous work undertaken for the United States, with adjustments made to reflect differences in Australian production systems.



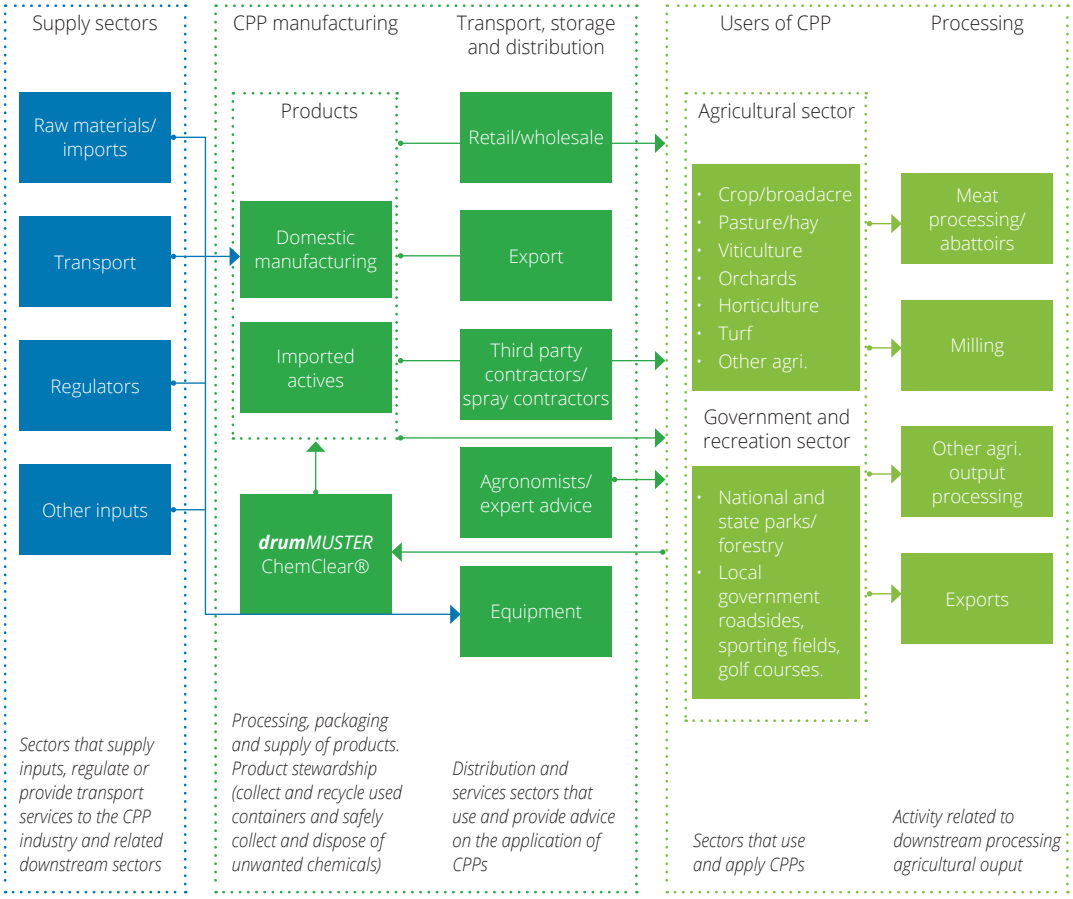
Economic contribution

The Australian CPP sector produced almost $2.9 billion in output in 2015–16, as measured at the factory gate (APVMA, 2017). This output was associated with an economic contribution of $2.3 billion, which consists of a direct economic contribution of $1 billion and indirect economic contribution of $1.3 billion in sectors supplying the CPP industry with intermediate inputs. These direct and indirect contributions are made up of the sector's gross operating surplus and wages.

In terms of employment, the CPP sector contributes 9,225 full time equivalent (FTE) employees, which consists of 1,725 directly in the CPP manufacturing sector and 7,500 in the sectors that supply inputs to the CPP sector. The primary industries contributing employment include: Professional, Scientific and Technical Services; Wholesale Trade; and Road Transport.

As illustrated in the following diagram, there are many economic linkages between the CPP sector, its upstream supply sectors, the distributors of CPP, the users of CPP and the downstream sectors that process the output from the users of CPP.

CPP industry linkages and relationships



Agricultural production attributable to CPP

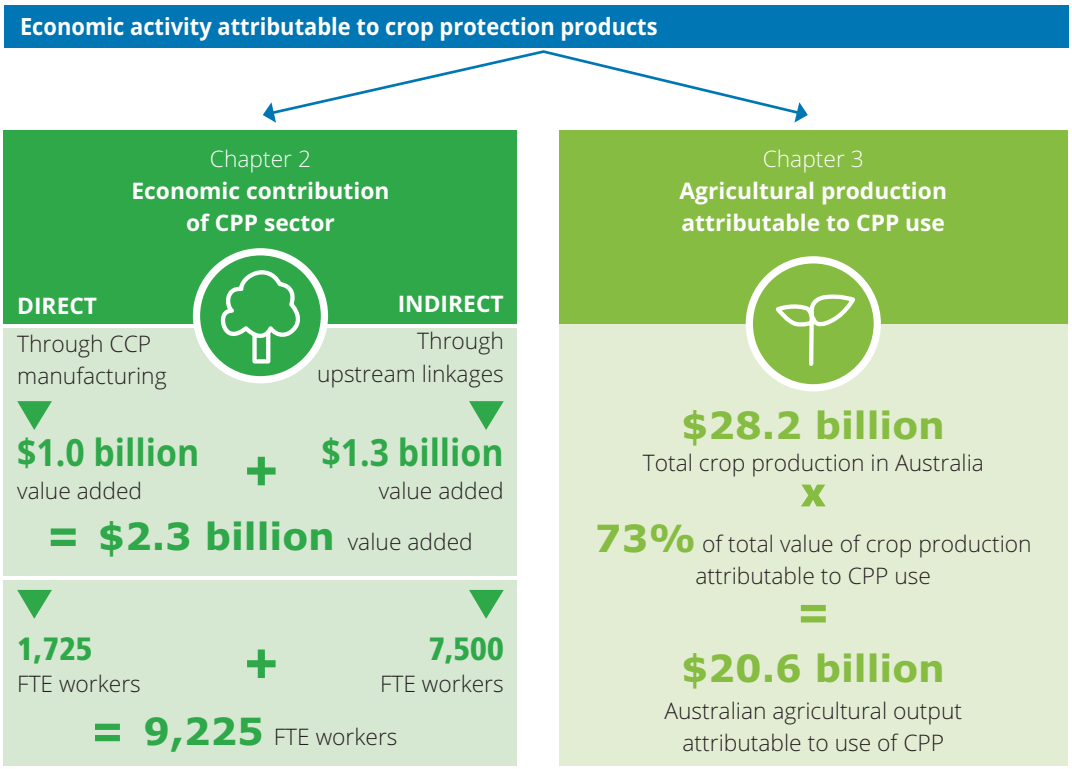
The total value of Australian crop production attributable to CPP is estimated as the sum of the attributable value of production for field crops (broadacre), vegetables, fruits and nuts and other crops (mostly forage crops). The output attributable to CPP is based on current farming practices, and assumes that all other necessary production inputs (sufficient water, nutrients, etc.) are available. The analysis does not consider the impact if all CPP suddenly become unavailable, which would necessitate significant changes to farming practices (and likely involve significant changes in crop mix and land use).

It is estimated that $20.6 billion of Australian agricultural output in 2015–16 was attributable to the use of CPP, or 73% of the total value of crop production in that year. Over half of this contribution is from fungicides, reflecting their significant contribution to the value of production of vegetables, fruits and nuts. This estimate includes the contribution to organic crop production, because chemicals used by organic producers, derived from naturally occurring substances, are crop protection products produced by the industry.

The value of crop production attributable to CPP use is different in kind to the contribution that the CPP industry makes to value added (i.e. its contribution to GDP). However, there is a level of value added associated with this amount of crop production. For each dollar of agricultural output, the direct plus indirect value added associated with that dollar is $0.87.[1] This means that the $20.6 billion of agricultural output that can be attributed to CPP use is associated with an economic contribution of $18.0 billion (consisting of gross operating surplus and wages in the crop production industry and businesses they purchase inputs from).

1 This is a weighted average based on which input-output product classification category the crop categories used in this fall into. 23% of crop production is classified as falling within industry 0101 (Sheep, Grains, Beef and DairyCattle) and 77% as falling with industry 0103 (Other Agriculture).

While this study does not consider or compare the private or broader benefits and costs of CPP use, or estimate the economic impacts that would occur if CPP products became unavailable and farming practices had to be modified, the results do indicate that CPP use makes a significant contribution to agricultural production in Australia, which would be greatly reduced if CPP were not to be used.



1 Background

Deloitte Access Economics was engaged by CropLife Australia to estimate the contribution of the crop protection products (CPP) industry to the Australian economy, and the Australian agricultural output attributable to the use of CPP. This report is an update of a similar piece of work that Deloitte Access Economics produced for CropLife Australia in 2013.

CPP include herbicides, fungicides and insecticides, which are widely used in many sectors of the economy. For industry — particularly agriculture — it is a means of increasing the productivity of land. Governments also use CPP to control invasive or non-native species on public land (such as roadsides and in national parks). They are also widely used by households for backyard gardening and pest control, in commercial buildings and maritime applications. That noted, this report focuses on the contribution of CPP in these agricultural and government uses, excluding use in households, buildings and maritime applications.

The scope of CPP is broad, and includes chemical products that are naturally occurring as well as chemicals which are synthetic. That is, the chemicals derived from naturally occurring substances, as used by the organic agriculture sector, are included as CPP.

This report presents estimates of the CPP industry's economic contribution and of the share of agricultural output attributable to the use of CPP. This study is not a cost-benefit analysis and does not consider or compare the relative magnitudes of costs in relation to the benefits; for example, costs to the environment and potential health implications of theiruse.

The CPP industry's economic contribution (the amount of value added involved in the production and sale of CPP) is a different concept to the amount of agricultural output that is attributable to the use of CPP. As such, the estimates of each of these (set out in Chapters 2 and 3, respectively) cannot be added together.

1.1 Crop protection products

Crop protection products include natural and synthetic chemicals used to control insects, diseases and weeds in food crops and plants. The three main groups that contribute to this part of the chemical industry are herbicides, fungicides and insecticides, contributing a total of 85% of product sales for the 2015–16 financial year (APVMA, 2017). Crop protection products in varying forms have improved the efficiency of the agriculture sector for over 150 years (Rhoades, 1963).

In Australia, agricultural chemicals are controlled by the Australian Pesticides and Veterinary Medicines Authority (APVMA) up until the point of final retail sale. This includes pre-market risk assessment, approval and registration of products as well as defining the content of labels describing instructions for safe and responsible use. States and territories control the use of products after this point including creating and administering rules for access to products, training and licensing of users, as well as any additional requirements for use such as record keeping or other restrictions.

As more products have been registered in recent years, the value of the CPP sales has continued to grow, highlighting the agricultural sector's acceptance of new chemical innovation, as shown in Chart 1.1. In the 2015–16 financial year, almost $2.9 billion was spent on over 8,900 registered crop protection products.

Chart 1.1: Crop protection products in Australia

Source: APVMA, 2017

These products can be classified in to four broad categories:

- **Herbicides** — products intended to prevent or reduce the growth of weeds. These can be either:
  - selective (chemicals which kill weeds specifically without harming crops); or
  - non-selective (chemicals which stop the growth of plants indiscriminately).
- **Insecticides** — chemicals which aim to control insects in plants and crops.
- **Fungicides** — products whose purpose is to prevent or manage fungal diseases in plants.
- **Other** — includes other pesticides (such as miticide, molluscicide, vertebrate poison) as well as chemical agents (adjuvants and surfactants).

Key reasons for use of CPP include:

- to decrease and control pests and diseases;
- to reduce the need for crops and plants to compete with weeds and other invasive plants;
- to increase the yield of crops or protect biodiversity; and
- to protect and maintain infrastructure such as buildings and roads through pest or weed control.

For this report, APVMA data on 'agricultural (pesticides) product sales' are used as indicative of CPP industry revenue. This includes all of the major categories of products used in crop production, as well as some products that may not be used in crop production (for example, 'household insecticides', 'pool products/algicide') but these make up a small share of total sales (see Table 2.1). The total value of agricultural (pesticide) product sales is used in the calculation of the economic contribution of the CPP industry because of the close links in the production and sale of all of those products, and the fact that the industry exists, by and large, to service the crop production sector.

1.2 Previous studies

Although crop protection products are well established worldwide, there is limited research on their economic contribution. This section details a few key studies.

The most comprehensive study undertaken to date is Mark Goodwin Consulting's 2011 report *The Contribution of Crop Protection Products to the United States Economy*. The Goodwin study was commissioned by CropLife America, and it details the value of selected crops which is attributable to CPP.

The study adopted a three-stage methodology. For each crop identified, Goodwin Consulting:

1 determined the proportion of crop value attributable to herbicides,insecticides and fungicides, using previous studies published by the Crop Protection Research Institute[2];

2 determined the total value of the crop by state; and

3 determined the total economic value attributable to agrochemical use by multiplying (1) and (2).

Aggregating, Goodwin concludes that that the direct contribution of crop protection products to the US economy is $81.8 billion, with flow-on benefits amounting to $166.5 billion across 20 industries, and approximately 1 million jobs across the country.

This study was followed by a similar report from, *Cultivating a vibrant Canadian economy*, published by CropLife Canada in 2011. This report considered the contributions of crop protection products as well as plant biotechnology.

After evaluating several potential methodologies, the Canadian report quantifies the contribution of agrochemicals by comparing yields between conventional and organic crops. It then calculates the value of crops attributable to crop protection products as the difference in yields multiplied by the price of crops.

The report concludes that, for the most commonly grown crops in Canada, the value generated by the increased yields associated with the use of agrochemicals and plant biotechnology is almost CA$8 billion.[3]

In Australia, the AECgroup published a report on the *Economic Impact of State and Local Government Expenditure on Weed and Pest Animal Management in Queensland* in 2002. The report conducted a cost benefit analysis of state and local government spending on a set of pest and weed management initiatives. One of the initiatives examined was the eradication of Siam Weed. The study found that every $1 spent on this program (including spraying, maintenance and border protection costs) resulted in between $9.90 and $26.80 of benefit.

A Deloitte Access Economics study from 2013 based on the methodology of the CropLife America report, adjusted appropriately for the Australian context, estimated that $17.6 billion of Australian crop production could be attributed to the use of CPP.

This report follows the methodology used in the 2013 Deloitte Access Economics study, which is detailed further in the following chapters.

2 Gianessi L and Regier N, 2006; Gianessi L and Regier N, 2005; Gianessi, 2009.
3 Including 16 field crops, 29 vegetable crops, 13 fruit crops and potatoes.

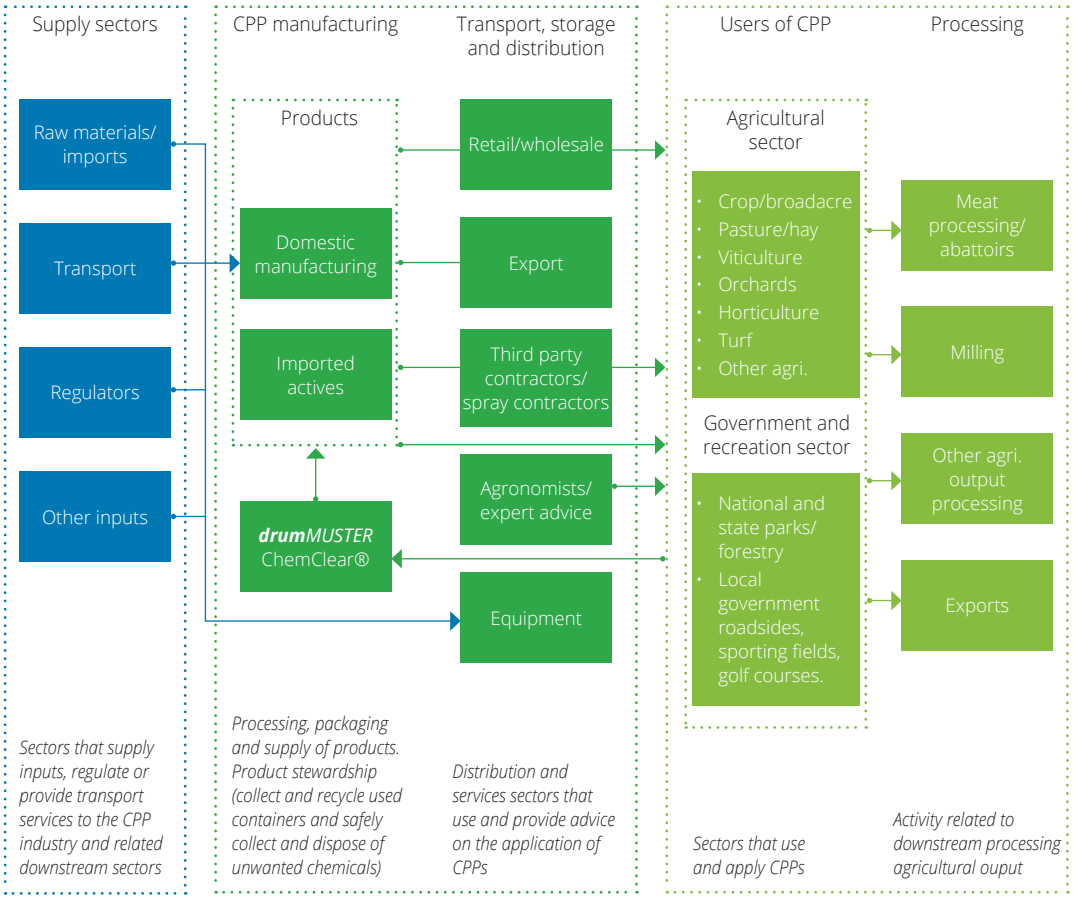
2 Economic contribution of CPP

This section outlines the economic contribution the CPP industry. This includes the direct economic contribution of the CPP industry and the indirect contribution associated with its purchases of intermediate inputs, as illustrated in Chart 2.1.

2.1 CPP industry linkages and relationships

The supply sectors include the third-party contractors like spray contractors and the agronomists that service the sector and help to optimise farm practices. It is noted that there are several types of agronomists. Some are employed by CPP companies (distribution agronomists), hence have their costs embedded in the retail cost of CPP as employees of chemical resellers. Private agronomists, on the other hand, independently generate revenue (over and above sales of CPP) through their work as consultants. These agronomists potentially add tens of million dollars per year, on top of the agronomist value included in CPP industry revenue, through their other work in areas such as crop nutrition and marketing. The value that private agronomists generate is not part of the analysis in this chapter.

Chart 2.1: CPP industry linkages and relationships



The CPP industry also provides the national product stewardship initiatives ***drum****MUSTER* and ChemClear®. ***drum****MUSTER* collects empty and clean agricultural chemical containers from participating manufacturers for recycling, providing an important tool to ensure containers are not stored on-farm, sent to landfill, buried or burnt. ChemClear® collects and safely disposes of obsolete agricultural chemicals from farms and other agvet chemical users. ***drum****MUSTER* commenced in 1999 and has collected over 30 million agvet chemical containers across Australia as of January 2018 according to its website (***drum****MUSTER*, 2018).

Further to these, the CPP industry-led Agsafe Accreditation and Training Program assists premises and personnel involved in the transportation, storage, distribution and sale of agricultural and veterinary chemicals (such as distributor's outlets and manufacturers' warehouses) to comply with the federal and state laws and regulations that apply to them.

Chart 2.1 also specifies the users of CPP products, including the agriculture, government and household sectors. The economic contribution discussion below outlines the total production of the CPP sector and provides a breakdown of the sectors of use.

2.2 Industry output

The Australian CPP industry produced almost $2.9 billion in output, in the Australian financial year 2015–16, as measured at the factory gate (APVMA, 2017). This figure has increased from the $2.5 billion figure measured in 2011–12.

The sector produces a wide array of products (a 'product' is a formulation of one or more active constituents ('actives') and other product elements), with herbicides, insecticides and fungicides making up 85% of sales. Herbicides alone account for nearly 60% of sales, worth around $1.7 billion in 2015–16. Insecticides accounted for 17% of sales (with 12% of these being insecticides for use on farms and 5% for use in households). Fungicides made up around 9% of sales.

The sector also provides a number of chemical products that are used in other sectors' production processes, such as dairy cleanser and wood preservatives. There are also a number of products that are used in aquatic applications; for example anti-fouling marine paints and water sanitisers for use in pools and spas. APVMA data also outlines that the sector produces $1.3 million in dog and bird repellents, consistent with the 2011–12 figures. The value of production of these products has been included in the calculation of the economic contribution of the CPP industry firstly because of the close links between the production and sale of the various types of products, and secondly because the industry as a whole exists, by and large, to service the crop production industry.

Table 2.1: Sector output by type of product $m, 2015–16

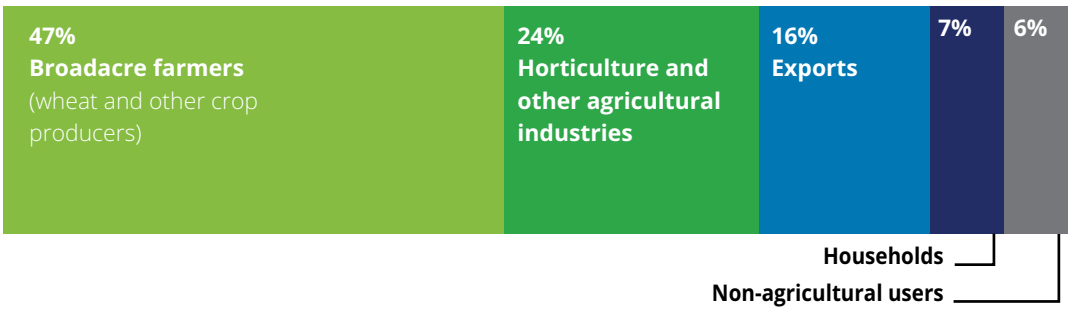
Output	$m (2015–16)	Share (%)
Adjuvants/surfactants	97.3	3.4
Anti-fouling — boat	16.7	0.6
Dairy cleanser	13.7	0.5
Disinfectant/sanitiser	11.3	0.4
Fungicide	254.1	8.8
Growth promoters/regulators	36.9	1.3
Herbicide	1,716.8	59.3
Household insecticide	152.0	5.2
Insecticide	337.5	11.7
Miscellaneous	5.1	0.2
Miticide	19.0	0.7
Mixed function pesticide	32.3	1.1
Molluscicide	11.8	0.4
Nematicide	4.2	0.1
Pool Products/algicide	67.2	2.3
Repellent — dogs/birds etc.	1.3	0.0
Seed treatments	48.4	1.7
Vertebrate poison	18.6	0.6
Wood preservative	52.4	1.8
Total	**2,896.5**	**100.0**

Source: APVMA, 2017.

2.3 Where are the products used?

As outlined above, actives are formulated into products and then distributed to a number of consumers. IBISWorld provides information on where the products that are produced in Australia are consumed. As expected, a high proportion (71%) are consumed in the agriculture sector, with broadacre industries using 47% of all CPP products. Within broadacre industries, the relative importance of various herbicides, fungicides and insecticides depend on the crop being grown. Horticulture and other agricultural industries then consume 24% of Australia's CPP products, with 16.1% of CPP products being exported, and the remaining used by households and other non-agricultural users. This market segregation is summarised in the following table.

Chart 2.2: Major market segmentation, 2015–16



Source: IBISWorld, 2016.

2.4 Sector economic contribution

This section provides estimates of the CPP industry's total economic contribution to the national economy. 'Economic contribution' refers to value added, which is equal to the sum of gross operating surplus and wages. The sum of value added across all industries in the economy equals GDP. The industry's total economic contribution is made up value added within the industry (its direct economic contribution), and value added generated in other industries through the supply of intermediate inputs to the CPP industry (its indirect economic contribution).

The CPP industry's total economic contribution is estimated using information on the value of CPP sales and the most recent 2014–15 Australian Bureau of Statistics (ABS) Input–Output tables. How the Input–Output tables are used is described in Appendix B.

Table 2.2 Economic contribution of CPP industry, 2015–16

Value added	**$m**
Direct — CPP	**1,041**
Gross Operating Surplus	472
Wages	569
Indirect — Supply sector	**1,252**
Gross Operating Surplus	618
Wages	635
Total	**2,293**
Gross Operating Surplus	1,089
Wages	1,203
Employment	**FTE**
Direct	1,725
Indirect	7,500
Total	9,225

Source: Deloitte Access Economics

The $2.9 billion in revenue generated by the sector contributes a total of $2.3 billion to value added. This is an increase of 26% from the $1.8 billion figure estimated in 2013. The CPP industry also contributes a total of 9,225 FTE employees. This has been relatively stable since 2013, where the industry supported a total of 9,250 FTE workers.

The CPP industry directly contributes over $1 billion to value added, comprising $472 million in gross operating surplus (GOS, essentially returns to capital) and $569 million in wages. The CPP industry also directly contributes 1,725 FTE jobs in Australia.

In addition, the CPP industry indirectly supports economic activity in upstream sectors through its demand for and use of intermediate inputs. In 2015–16, the CPP industry indirectly contributed $1.25 billion to value added, and supported a further 7,500 FTE jobs in Australia.

A breakdown of indirect value added by industry is given in Table 2.3. For instance, professional, scientific and technical services captures the largest share of indirect value added resulting from the CPP's demand for intermediate inputs, at 9.7%, or $122 million. It also makes up 14.1% of total indirect employment, at 1,060 jobs.

The increase in the economic contribution of the CPP industry since the 2013 analysis has been driven by an increase in product sales, from $2.5 billion to $2.9 billion. There has also been an increase in the size of the industry's direct economic contribution relative to its indirect economic contribution which increases the total economic contribution of the industry for any given level of product sales.

Table 2.3: Indirect contribution of CPP industry, 2015–16

Industry value added	**$m**	**Share of indirect contribution (%)**
Professional, Scientific and Technical Services	122	9.7
Oil and gas extraction	99	7.9
Basic Chemical Manufacturing	90	7.2
Wholesale Trade	84	6.7
Non-Residential Property Operators and Real Estate Services	81	6.4
Other industries	777	62.1
Total	1,252	100.0
Industry employment contributions	**FTE**	**Share of indirect contribution (%)**
Professional, Scientific and Technical Services	1,060	14.1
Wholesale Trade	501	6.7
Road Transport	371	4.9
Non-Residential Property Operators and Real Estate Services	354	4.7
Other Repair and Maintenance	320	4.3
Other industries	4,895	65.3
Total	7,500	100.0

Source: Deloitte Access Economics

3 Australian agricultural production attributable to CPP

This chapter presents the methodology and estimation of the Australian agricultural production attributable to CPP. This estimate cannot be compared with economic statistics such as GDP. Rather, it is an estimate of the amount of output from crop production that is attributable to CPP. For many agricultural crops (particularly horticultural and tree crops) it would not be possible to produce a crop without the use of CPP, or yields would decline substantially without the use of CPP. The estimates of agricultural production attributable to CPP capture this reality.

Importantly, the value of agricultural production attributable to CPP is not the same as the 'economic impact' that would occur in a scenario where all CPP became unavailable — such a scenario may involve changes in behaviour and changes in farm practices that partly offset the absence of CPP. Rather, this report estimates the current production attributable to CPP (in 2015–16) based on current farm practices.

The methodology for estimating the contribution of CPP is based on work by Mark Goodwin Consulting (2011) and the scientific literature on attributions of different crops that underpinned that report. The report was commissioned by CropLife America, and detailed the value of selected crops attributable to CPP (specifically herbicides, insecticides and fungicides).

Deloitte Access Economics has adjusted previous estimates of the contribution of CPP to the production of different crops in the USA to reflect salient features of Australian production practices. Differences in crop mix between the USA and Australia also impact the value of Australian agricultural production attributable to CPP. Each of these is discussed in Sections 3.1 and 3.2.

The value of CPP to Australian crop production in 2015–16 is discussed in Section 3.3.

3.1 The 'island' factor

Australia and the USA have very different agricultural industries due to a number of factors.

- **Climate and rainfall** — Australia generally has a warmer, drier climate which affects growth of weeds as well as crops.
- **Australia is an island continent** — geographic isolation from other countries and a rigorous quarantine system limit the prevalence of overseas crop pests and diseases. On the other hand, there are some pests and diseases unique to Australia, such as the native Queensland fruit fly.
- **Soils** — Australia is an old continent, with soils older and less fertile than those in the USA. This has implications for fertiliser use and plant competition from weeds and hence use of CPP.
- **Agricultural practices** — minimum tillage and GPS-controlled cropping systems have been adopted more quickly in Australia than in the USA (Australian Farm Institute, 2012) which can have an effect on soil-borne pests and diseases and need for pesticides. American agricultural production has a greater penetration of genetically modified crops (such as corn and soy) which can reduce the requirement of CPP inputs into these farming systems, particularly where crop varieties are resistant to specific pests and diseases.
- **Labour costs** — Australian agricultural sector wages are around double those in the United States, which could make farmers more likely to use CPP in Australia to reduce reliance on labour (Australian Farm Institute, 2012).

An effect of these differences in agricultural industries is different use of CPP in production. For example, application rates of particular pesticides vary, which entails differences in the use of CPP per unit of production and per unit of cropping area.

A factor is applied to the USA data to make it applicable to the Australian context. This 'island' factor takes into account the differences in agricultural production outlined above through a ratio comparing CPP use in Australia and the USA. This is summarised in Table 3.1 below.

Table 3.1: The 'island' factor

	Australia (average 2007–16)	USA (average 2007, 2012)
Total CPP use (million USD)	$1,770	$8,640
Total crop area (million ha)	27.4	161.1
Total crop production (million USD)	$23,722	$195,036
CPP use/ha (USD/ha)	$64.73	$53.64
CPP use/$ production (USD)	$0.075	$0.044
'Island' factor (ha)	1.21	
'Island' factor (production)	1.68	
Average 'island' factor	**1.45**	

Source: RBA (2017), APVMA (2017), ABS (2017a), ABS (2017b), Atwood and Paisley-Jones (2017), USDA (2014), US Bureau of Labour Statistics (2017). Note: All dollar values used have been converted to 2016 dollars.

Data for Australian spend on CPP, crop area and the value of total crop production was collected for 2006–07 to 2015–16 inclusive. Using the average across these years allows the methodology to account for differences in the use of CPP across different growing conditions.

Average figures over this time period accounted for the different growing conditions in drought years (for example 2006–07) and higher production in non-drought years (2011–12). American data was collected for 2007 and 2012, the years for which Agriculture Census data are available.

All values were converted to USD using yearly average exchange rates to make them comparable across countries. CPP use per hectare and CPP use per dollar of production were then estimated from the above data. Australian CPP use per hectare was divided by American CPP use per hectare to derive an 'island' factor of 1.21. Similarly, Australian CPP use per dollar of production was divided by American CPP use per dollar of production to derive an 'island' factor of 1.68. The average of these provided an average 'island' factor of 1.45.

While there may be lower incidence of international pests and diseases affecting crop production in Australia, CPP use in Australia may be higher due to a greater preference for minimum tillage technologies (which are complemented by chemical weed control, rather than mechanical weed control) and higher labour costs that may limit the adoption of more labour-intensive and less chemical-intensive methods of pets and diseases management.

As discussed in the following section, the relative crop mix also affects the use of pesticides in agriculture, with horticulture representing a greater proportion of production in the USA compared to Australia.

The 'island' factor used in this report is higher than the value of 1.26 calculated for use in the 2013 report. This is largely due to the addition of the 2012 data point for the calculation of CPP use per unit area in the USA.

3.2 The Australian crop mix

In addition to the differences accounted for in the previous section, the Australian crop mix also differs from production in the USA. To some degree, the factors outlined above affect the relative proportions of crops produced in both countries.

Crops can be categorised into four broad categories:

- broadacre crops;
- vegetables;
- fruits and nuts; and
- other crops (mostly forage crops produced for livestock consumption).

The relative proportions of these crop groups have implications for the contribution of CPP. In particular, higher applications of CPP are generally used in high-value horticultural production compared to broadacre cropping. The Australian crop mix has a higher share of horticultural production compared to the USA.

The share of production attributable to CPP use varies among individual crops within each category. For example, the proportion of production attributable to CPP is higher for potatoes than it is for barley.

These differences are accounted for in the calculation of the proportion of the total value of production of each broad category attributable to CPP use.

Table 3.2: Crop production, Australia and the USA

	Australia (2015–16)		**USA (2012)**	
	$m	%	$m	%
Field crops (broadacre)	16,383	59	127,917	60
Vegetables	5,180	18	17,640	8
Fruits and nuts	4,912	17	26,895	13
Other crops	1,600	5	39,945	19
Total crops	**28,175**	**100**	**212,397**	**100**

Source: ABARES (2016), USDA (2014). Note: The values for each crop category for the USA are not drawn directly from the US Agriculture Census data. The proportion of the value of production that each category represents of the value of crop product ion on cropping farms is multiplied by the total value of crop production (which also includes some crop production on livestock farms).

3.3 Value of CPP to Australian crop production

Gianessi (2005, 2006 and 2009) conducted a series of studies on the contribution of fungicides, herbicides, insecticides to crop production in the USA. These studies presented data by crop, for the share of value attributable to each product. A summary of this data is provided at Appendix A.

Mark Goodwin Consulting combined the findings of these studies in his 2011 report to provide an overall estimate of the contribution of CPP for the USA. This was done by adding the herbicide, insecticide and fungicide percentage contributions to provide a total CPP contribution. These sums were capped at 100% even if the individual herbicide, insecticide and fungicide contributions exceeded this amount.

For this study, the crops were split into the four crop categories of: field crops, vegetables, fruit and nuts, and other crops. Average herbicide, insecticide and fungicide contributions to the production for each crop category were then estimated based on the mix of individual crops. This is separately described for each crop group below.

These averages were then multiplied by the 'island' factor to determine the Australian contribution to production. Finally, these contributions were multiplied by the value of crop production in the four groups (field crops (broadacre), vegetables, fruit and nuts, and other crops) to calculate the value of Australian agricultural production attributable to CPP use.

Field crops (broadacre)

Field crops include barley, canola, cotton, sorghum, sugarcane and wheat, among other crops. The full list of crops in this category is shown in Appendix A.

Within this category of crops, the proportion of value attributable to herbicide ranges from 16% for sunflowers up to 53% for rice. Overall, corn and sorghum are relatively hardy, with a smaller proportion of total production being attributable to CPP (23% and 34% of value attributable to CPP, respectively).

The value contribution of herbicide, insecticide and fungicide was estimated based on data from Gianessi (2005, 2007 and 2009), weighted for the Australian crop mix by value of production. Wheat and sugarcane combined make up over half of the value of these broadacre crops in Australia.

Adjusting for differences in use of CPP in Australian agriculture, these weighted average contributions were then multiplied by the 'island' factor. This produces an overall contribution to the value of Australian broadacre production of 58%. Herbicides make up more than half of this, with a contribution of 34% of crop value. In dollar terms, the contribution of CPP to Australian broadacre production is estimated at $9.6 billion. This is an increase over the $7.7 billion figure estimated for 2011–12, and is driven by an increase in the value of production, an increase in the 'island factor' (discussed in Section 3.1) and a slight shift in crop mix towards crops for which fungicides make a greater contribution to production.

Table 3.3: CPP contribution to value of field crops (broadacre)

	Herbicide	Insecticide	Fungicide	Total CPP
Weighted average contribution (%)	24	8	11	40
Australian contribution (%)	34	12	15	58
Value to Australia ($m)	5,661	1,934	2,539	9,622

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics.

Vegetables

Crops included in this category include broccoli, carrots, lettuce and onions, with a full list included in Appendix A. For the purposes of estimation, herbs have been included in this category.

Vegetable crops have a relatively high dependence on CPP, in particular fungicides. Onions, for example, attribute 100% of their production to fungicides and CPP accounts for 95% and 92% of crop value for carrots and celery respectively. That is, these vegetables would be very difficult to grow commercially without the use of CPP.

In the absence of sufficiently detailed data to weight the mix of vegetable crops by value or volume of Australian production, an average was taken of the contribution of herbicides, insecticides and fungicide contributions for the range of crops analysed by Gianessi (2005, 2007 and 2009).

The contribution of each type of CPP product to vegetable production was calculated by multiplying the total value of vegetable production by the average percentage of production attributable to CPP use across the range of crops for which Giannessi provided estimates (multiplied by the 'island' factor).

Calculating the contribution of CPP use as a whole to vegetable production first requires summing the percentage of production attributable to each CPP category, which in many cases is greater than 100%.

The simple average of these is taken, which equals 83%, and then multiplied by the 'island' factor of 1.42 to calculate the contribution of CPP use as a whole to Australian vegetable production.

Using this method produces the result that 100% of Australian vegetable production — $5.2 billion in 2015–16 — is attributable to the use of CPP. The increase over the estimate produced for 2012 is solely due to the increase in the value of vegetable production (because, as in the 2013 analysis, 100% of the value of vegetables is attributed to the use of CPP).

Along with CPP, vegetables also require water, labour and land to produce a crop. The use of (say) water could also be attributed with 100% of onion output, as without water there would obviously be no production. As such, the estimates here should be interpreted as the amounts of production attributable to CPP, assuming all other requisites for production (water, labour, etc.) are readily available.

Table 3.4: CPP contribution to value of vegetables

	Herbicide	Insecticide	Fungicide	Total CPP
Weighted average contribution (%)	21	34	54	83
Australian contribution (%)	30	49	78	100
Value to Australia ($m)	1,540	2,528	4,029	5,180

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics.

Fruits and nuts

The fruits and nuts category includes apples, almonds, bananas, grapes, oranges and peanuts among others. The full list is presented in Appendix A.

Similar to vegetables, the value of fruits and nuts are more dependent on fungicides than other CPP, and have a relatively small contribution from herbicides. Grapes and papaw are particularly reliant on fungicides, with 100% of their value attributed to their use according to the Gianessi estimates. Peanuts and almonds attribute 92% and 70% of production to fungicide use, respectively.

The weighted average contribution of herbicides, insecticides and fungicides was estimated using data on the value of production of the relevant crops. This is preferred to the approach of using a weighted average based on volume (which had to be used in the 2013 report due to insufficient value data) or a simple average (which has been used for vegetables due to insufficient volume or value data).

Multiplying by the 'island' factor provides the estimate for the contribution of CPP to Australian agricultural production. While fungicide alone accounts for 100% of fruits and nuts production on average, and the contribution of all CPP is capped at 100%, herbicides and insecticides also contribute to the value of production.

As with vegetables, 100% of the value of fruit and nuts production is attributed to the use of CPP under the methodology used. This is primarily due to the import role of insecticides in the production of a number of major crops, including apples and grapes.

The total value of CPP use on fruits and nuts production in Australia is estimated to be valued at $4.9 billion (the total value of fruit and nut production). As with vegetables, the increase over the figure of $4.0 billion in 2013 is entirely due to the increase in the value of fruit and nut production.

Table 3.5: CPP contribution to value of fruits and nuts

	Herbicide	Insecticide	Fungicide	Total CPP
Weighted average contribution (%)	8	47	75	94
Australian contribution (%)	11	68	100	100
Value to Australia ($m)	564	3,347	4,912	4,912

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics.

Other crops

This category of crops is mainly comprised of forage crops; those grown specifically to be grazed by livestock or conserved as hay or silage. The contribution of CPP to value of production for these crops is assumed to be the same as for broadacre crops. Adjusting by the 'island' factor suggests a contribution of 58% of the value of production. In dollar terms, this is estimated at $934 million, a slight increase over the figure of $865 million estimated in 2013.

Table 3.6: CPP contribution to value of other crops

	Herbicide	Insecticide	Fungicide	Total CPP
Weighted average contribution (%)	24	8	11	40
Australian contribution (%)	34	12	15	58
Value to Australia ($m)	549	188	246	934

Source: Mark Goodwin Consulting 2011, Deloitte Access Economics.

3.4 Results summary

The total value of CPP to Australian crop production is calculated as the sum of their contribution to each of the four categories of crops discussed in Section 3.3.

In aggregate, it is estimated that $20.6 billion of cropping production is attributable to the use of CPP, or 73% of the total value of crop production in 2015–16. Over half of this contribution is from fungicides, reflecting their significant contribution to the production of vegetables, fruit and nuts. This estimate includes the contribution of organic crop production, which uses CPP derived from natural substances. A summary of the results discussed in Section 3.3 is produced in Table 3.7.

Table 3.7: CPP contribution to Australian crop production

	Herbicide	Insecticide	Fungicide	Total CPP
Field crops (broadacre) ($m)	5,661	1,934	2,539	9,622
Vegetables ($m)	1,540	2,528	4,029	5,180
Fruits and nuts ($m)	564	3,347	4,912	4,912
Other crops ($m)	549	188	246	934
Total ($m)	**8,314**	**7,997**	**11,727**	**20,648**

Source: Deloitte Access Economics.

The value of Australian crop production attributable to CPP in 2016 is 17% higher than the equivalent that was calculated for 2012. This result is driven by an increase in the 'island' factor, which has been updated for this report using additional data on CPP use, cropping area and the value of crop production. It is also partly attributable to an increase in the value of crop production in Australia.

The value of crop production attributable to CPP use is different in kind to the contribution that the CPP industry makes to value added (i.e. its contribution to GDP). However, there is a level of value added associated with this amount of crop production. For each dollar of agricultural output, the direct plus indirect value added associated with that dollar is $0.87.[4] This means that the $20.6 billion of agricultural output that can be attributed to CPP use is associated with an economic contribution of $18.0 billion.

4 This is a weighted average based on which input output industry group the crop categories used in this fall into. 23% of crop production is classified as falling within IOIG 0101 (Sheep, Grains, Beef and Dairy Cattle) and 77% as falling within IOIG 0103 (Other Agriculture).

4 Conclusion

This report presents an economic contribution of CPP and an estimate of its value based on the share of yield attributable to use of CPP.

The CPP industry has a number of linkages to other sectors. These include sectors that provide inputs into production and those that provide services to the users of CPP products, such as spray contractors and agronomists. The users of CPP include the agriculture, government and household sectors.

The Australian CPP industry produced almost $2.9 billion in output in 2015–16. Its total economic contribution was $2.3 billion to value added and 9,225 FTE employees. This has grown 26% since the 2013 Deloitte Access Economics estimation of $1.8 billion. The increase in the economic contribution of CPP in comparison to the 2013 estimate has been driven by growth in product sales, and a shift towards more industry revenue staying within the industry as direct value added (rather than becoming value added in industries supplying the CPP industry with intermediate inputs).

In terms of contribution to the value of crop production, it is estimated that $20.6 billion of Australian crop production was attributable to CPP use in 2015–16, or 73% of the total value of crop production in that year (where CPP includes synthetic chemicals widely used in conventional agricultural production and chemicals derived from natural substances used in organic production). This production is associated with around $18.0 billion in direct plus indirect value added.

Fungicides have the largest contribution to agricultural production, due to their important role in the production of vegetables and fruit and nuts. Herbicides are relatively less important for vegetable and fruit and nut crops, but are by far the most important type of CPP used in the production of field crops, which do make up over half of the value of crop production in Australia.

The estimated $20.6 billion of crop production attributable to CPP use in Australia in 2015–16 had grown considerably since the 2013 estimation of $17.6 billion. This increase is largely driven by an increase in the 'island' factor used to modify estimates of the percentage of crop production attributable to CPP use in the USA for use in an Australian context. This conversion is necessary because it is assumed that the value of CPP expenditure per unit area and per dollar of crop production are indicators of the contribution that CPP use makes to crop production. The 'island' factor has increased due to the data on crop production and CPP use in Australia and the USA indicating small growth in the value of CPP use per dollar of crop production in Australia and a decrease in the USA since the 2013 Deloitte Access Economics report. There has also been some change in the Australian crop mix towards crops that are more reliant on CPP for their production, but this is of secondary importance.

While this study does not consider or compare the private or broader benefits and costs of CPP use, or estimate the economic impacts that would occur if CPP products became unavailable and farming practices had to be modified, the results do indicate that CPP use makes a significant contribution to agricultural production in Australia. In the absence of CPP use, agricultural production in Australia would be significantly affected. The estimates of the contribution of CPP use to crop production should be interpreted as indicating the contribution they make to crop production, assuming that all other necessary inputs (water, nutrients, etc.) are available in sufficient quantities.

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Appendix A — Gianessi data

Table A.1: Share of yield attributable to CPP (%)

Crop	Herbicide	Insecticide	Fungicide	Total CPP	Category*
Alfalfa		5		5	V
Almond	5	43	70	100	FN
Apple	15	93	86	100	FN
Artichoke	16	60	35	100	V
Asparagus	55	67	22	100	V
Avocado		48		48	FN
Banana			75	75	FN
Barley			9	9	FC
Blueberry	67	69	75	100	FN
Broccoli	14	75		89	V
Cabbage		64	65	100	V
Canola	45			45	FC
Cantaloupe			60	60	FN
Carrot	48	10	95	100	V
Celery	0	48	92	100	V
Cherries		84	92	100	FN
Citrus	0		88	88	FN
Collard			78	78	V
Corn	20	3		23	FC
Cotton	27	30	12	69	FC
Cranberry	50	50	87	100	FN
Cucumber	66	34	77	100	V
Date		85		85	FN
Dry bean	25			25	FC
Eggplant		25		25	V
Garlic			61	61	V
Grape	1	35	100	100	FN
Green bean	20	58	65	100	V
Green pea	20	22		42	FC
Hazelnut		45	60	100	FN
Hop	25	100	100	100	FC
Hot pepper	0		44	44	V

Crop	Herbicide	Insecticide	Fungicide	Total CPP	Category*
Kiwi			33	33	FN
Lettuce	13	50	85	100	V
Mint	58	54	16	100	V
Nectarine		64	89	100	FN
Olive		90	84	100	FN
Onion	43	22	100	100	V
Orange		77		77	FN
Papaya			100	100	FN
Parsley			66	66	V
Peach	11	51	91	100	FN
Peanut	52	55	92	100	FN
Pears		85	89	100	FN
Pecan		56	72	100	FN
Pistachio		64	39	100	FN
Plums & prunes			66	66	FN
Potato	32	29	94	100	FC
Raspberry	0	55	97	100	FN
Rice	53	13	54	100	FC
Sorghum	26	8		34	FC
Soybean	26	5	3	34	FC
Spinach	50	16	71	100	V
Strawberry	30	56	97	100	FN
Sugar beet	29	23	78	100	V
Sugarcane	25	22		47	FC
Sunflower	16	50		66	FC
Sweet corn	25	28	36	89	FC
Sweet peppers		53	80	100	V
Sweet potato	20	45		65	V
Tomato	23	53	77	100	FN
Walnut		36	54	90	FN
Wheat	25	3	9	37	FC
Wild Rice	50		20	70	FC

Sources: Gianessi 2005, 2006 and 2009. *Note: categories FC=field crop (broadacre), V = vegetables (includes herbs), FN = fruits and nuts.
Blanks indicate no data was available.

Appendix B — Economic contribution analysis

B.1 Analysis introduction

Economic contribution studies are intended to quantify measures such as value added, exports, imports and employment associated with a given industry or firm, in a historical reference year. The economic contribution is a measure of the value of production by a firm or industry.

All direct, indirect and total contributions are reported as gross operating surplus (GOS), labour income, value added and employment (with these terms defined in Table B.1).

Table B.1: Definitions of economic contribution estimates

Estimate	Definition
Gross operating surplus (GOS)	GOS represents the value of income generated by the entity's direct capital inputs, generally measured as the earnings before interest, tax, depreciation, and amortisation (EBITDA).
Labour income	Labour income is a subcomponent of value add. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.
Value added	Value added measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals GDP. Given the relationship to GDP, the value added measure can be thought of as the increased contribution to welfare.
Employment (FTE)	Employment is a fundamentally different measure of activity to those above. It measures the number of workers (measured in full-time equivalent terms) that are employed by the entity, rather than the value of the workers' output.
Direct economic contribution	The direct economic contribution is a representation of the flow from labour and capital committed in the economic activity.
Indirect economic contribution	The indirect contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by economic activity.
Total economic contribution	The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Source: Deloitte Access Economics, 2018

B.2 Definitional notes

When calculating the GOS for a typical for-profit firm or industry, income streams from government (such as transfers or production subsidies) are excluded as they are a transfer of public funds, not reflective of income generated by the activities of the firm or industry.

Similarly, value added is typically calculated as GOS plus labour income net of subsidies; under the ABS Australian System of National Accounts (ASNA) (ABS 2013):

> A subsidy on a product is a subsidy payable per unit of a good or service. An enterprise may regard a subsidy as little different from sales proceeds. However, in the national accounts, subsidies are regarded as transfer payments from general government, enabling enterprises to sell their output for less than would otherwise be the case.

B.3 Value added

The measures of economic activity provided by this contribution study are consistent with those provided by the Australian Bureau of Statistics. For example, value added is the contribution the sector makes to total factor income and gross domestic product (GDP).

There are a number of ways to measure GDP, including:

- **expenditure approach** — measures expenditure: of households, on investment, government and net exports; and
- **income approach** — measures the income in an economy by measuring the payments of wages and profits to workers andowners.

Below is a discussion measuring the value added by an industry using the income approach.

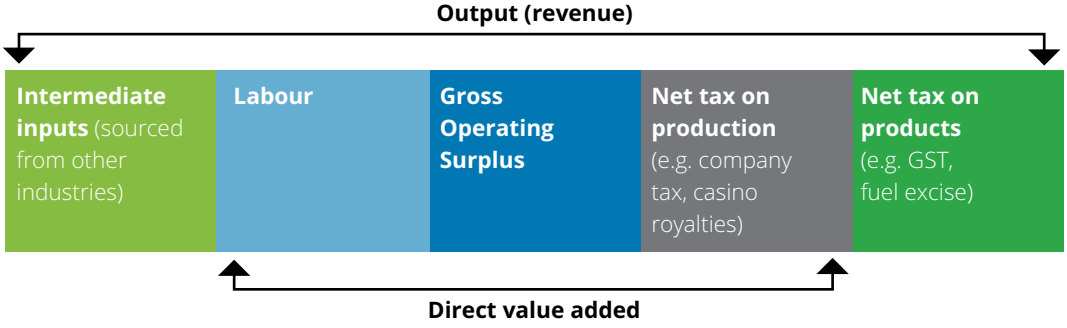
B.4 Measuring the economic contribution — income approach

There are several commonly used measures of economic activity, each of which describes a different aspect of an industry's economic contribution:

- **Value added** measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product. Given the relationship to GDP, the value added measure can be thought of as the increased contribution towelfare.
  Value added is the sum of:
  - Gross operating surplus (GOS) represents the value of income generated by the entity's capital inputs, generally measured as the earnings before interest, tax, depreciation and amortisation (EBITDA).
  - Tax on production less subsidy provided for production. Note: given the manner in which returns to capital before tax are calculated, company tax is not included or this would double-count that tax. In addition it excludes goods and services tax, which is a tax on consumption (i.e. levied on households).
  - Labour income is a subcomponent of value added. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour.

Figure B.1 shows the accounting framework used to evaluate economic activity, along with the components that make up output. Output is the sum of value added and the value of intermediate inputs used by the firm or industry. The value of intermediate inputs can also be calculated directly by summing up expenses related to non-primary factor inputs.

Figure B.1 Economic activity accounting framework



Source: Deloitte Access Economics.

Contribution studies generally outline employment generated by a sector. Employment is a fundamentally different measure of activity to those above. It measures the number of workers that are employed by the entity, rather than the value of the workers' output.

B.5 Direct and indirect contributions

The **direct** economic contribution is a representation of the flow of labour and capital to businesses in the CPP industry.

The **indirect** contribution is a measure of the demand for goods and services produced in other sectors as a result of demand generated by the direct economic activity of the CPP industry. Estimation of the indirect economic contribution is undertaken in an input–output (IO) framework using Australian Bureau of Statistics IO tables which report the inputs and outputs of specific sectors of the economy (ABS 2017).

The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Other measures, such as total revenue or total exports are useful measures of economic activity, but these measures alone cannot account for the contribution made to GDP. Such measures overstate the contribution to value added because they include activity by external firms supplying inputs. In addition, they do not discount the inputs supplied from outside Australia.

B.6 Limitations of economic contribution studies

While describing the geographic origin of production inputs may be a guide to a firm or industry's linkages with the local economy, it should be recognised that these are the type of normal industry linkages that characterise all economic activities.

Unless there is unused capacity in the economy (such as unemployed labour) there may not be a strong relationship between a firm's economic contribution as measured by value added (or other static aggregates) and the welfare or living standard of the community. The use of labour and capital by demand created from the industry comes at an opportunity cost as it may reduce the amount of resources available to spend on other economic activities. This is not to say that the economic contribution, including employment, is not important. As stated by the Productivity Commission in the context of Australia's gambling industries: (Productivity Commission 1999):

> Value added trade and job creation arguments need to be considered in the context of the economy as a whole … income from trade uses real resources, which could have been employed to generate benefits elsewhere. These arguments do not mean that jobs, trade and activity are unimportant in an economy. To the contrary they are critical to people's well-being.However,anyparticularindustry'scontributiontothesebenefitsismuchsmaller than might at first be thought, because substitute industries could produce similar, though not equalgains.

In a fundamental sense, economic contribution studies are simply historical accounting exercises. No 'what-if', or counterfactual inferences — such as 'what would happen to living standards if the firm or industry disappeared?' — should be drawn from them.

The analysis — as discussed in the report — relies on a national IO table modelling framework and there are some limitations to this modelling framework. The analysis assumes that goods and services provided to the sector are produced by factors of production that are located completely within the state or region defined and that income flows do not leak to other states.

The IO framework and the derivation of the multipliers also assume that the relevant economic activity takes place within an unconstrained environment. That is, an increase in economic activity in one area of the economy does not increase prices and subsequently crowd out economic activity in another area of the economy. As a result, the modelled total and indirect contribution can be regarded as an upper-bound estimate of the contribution made by the supply of intermediate inputs.

Similarly the IO framework does not account for further flow-on benefits as captured in a more dynamic modelling environment like a Computerised General Equilibrium (CGE) model.

B.7 Input-output analysis

Input–output tables are required to account for the intermediate flows between sectors. These tables measure the direct economic activity of every sector in the economy at the national level. Importantly, these tables allow intermediate inputs to be further broken down by source. These detailed intermediate flows can be used to derive the total change in economic activity associated with a given direct change in activity for a given sector.

A widely used measure of the spill-over of activity from one sector to another is captured by the ratio of the total to direct change in economic activity. The resulting estimate is typically referred to as 'the multiplier'. A multiplier greater than one implies some indirect activity, with higher multipliers indicating relatively larger indirect and total activity flowing from a given level of direct activity.

The IO matrix used for Australia is derived from the ABS 2014–15 IO tables, the latest available IO data at the time of the analysis. The industry classification used for IO tables is based on the Australian and New Zealand Standard Industrial Classification (ANZSIC), with 114 sectors in the modelling framework.

Limitation of our work

General use restriction

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