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Agricultural export price and volume indicators

Concepts, data sources and methods

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Summary

This paper introduces new agricultural export price and volume indicators. These indicators cover a gap in the available agricultural export statistics and will provide further insights into Australian agricultural exports.

The new indicators form an export account and provide disaggregated price and volume indicators across Australian agricultural sectors and industries. The indicators have been compiled on a monthly, quarterly and annual basis.

The indexes are constructed using the Fisher index formula. The Fisher index was chosen because of its useful economic and statistical properties that allow for decomposition analysis and to provide consistent estimates despite underlining volatility.

Introduction

Background

The value of exports is made up of two components, the quantity exported (referred to here as its volume) and the unit price. Analysis of the export value of an individual good and its volume and price components is relatively straight forward and is the basis for much of ABARES' analysis, forecasts, modelling and economic commentary.

Rather than just communicating commodity specific developments, there is a policy need to understand developments across industries and sectors. This task is made easier with the use of aggregated data. For example, it is easier to interpret and to identify trends in a single export price index for the cropping sector, than it is to identify common trends across many individual commodity prices. A single index can also be more informative and useful in understanding broader developments.

This paper outlines the recent development of aggregate price and volume indicators for Australian agricultural exports. The development of these indicators is couched in an accounting framework to ensure consistency across multiple levels of aggregation and index frequency.

These price and volume indicators have been used in a number of ABARES publications, for example, *Agricultural commodities* and *Snapshot of Australian agriculture*. The aim of these indicators is to shed light on developments and trends in the agricultural sector that are difficult to see at the individual commodity level.

This paper documents the concepts, sources and methods that have been used to produce the Australian export price and volume indicators.

Structure of the paper

Chapter 1 provides an overview of Australian agricultural exports. It demonstrates the importance of exports to the sector and to rural communities, and the need for indicators that can effectively monitor the developments in the value of exports over time.

Chapter 2 reviews the publicly available price and volume indicators. It finds that the available options provide limited utility due to a lack of disaggregation and vastly different coverage, data and methodologies. Chapter 3 provides a justification for producing price and volume indicators, including to overcome the limitations of the currently available measures.

Chapters 4 to 6 describe the foundations for the construction of export price and volume indicators. Chapter 4 explains the measurement approach for constructing the indicators—price indexes are measured directly and volume indicators are derived from the value and price indexes. Because of this approach, Chapters 5 and 6 focus on the formulation of price indexes. Chapter 5 introduces price index theory and explains why a Fisher formula is adopted, noting that it has the properties required to derive volume indicators. Chapter 6 outlines how the Fisher formula is applied in practice, with a focus on the monthly export price index, and the benchmarking techniques to ensure the monthly indicators are consistent with the indicators derived on an annual basis.

Finally, chapter 7 presents the results of the monthly, quarterly and annual price and volume indicators. The focus is on presenting the price indicators. Possible avenues of research and comparisons with other price indexes are made. Chapter 8 discusses the various technical hurdles that arose when constructing the monthly agricultural export price index, including index drift.

1 An overview of Australian agricultural exports

Australia is a prominent agricultural exporter. According to the World Trade Organisation, Australia was the 13th largest agricultural exporter in 2015, with 2.3 per cent of the value of world agricultural exports (WTO 2017). The largest agricultural exporters were the European Union (37 per cent of global trade, with the Netherlands, Germany and France being the top three agricultural exporters from that region), the United States (10 per cent) and Brazil (5 per cent). These countries compete with Australia in most of Australia's largest export markets, including beef and veal, wheat and barley.

Australian producers are considered price takers in international agricultural commodity markets. This means that Australian producers cannot unilaterally influence global commodity prices which are determined by global demand and supply dynamics, particularly in the long term. A good example of this is wool. While Australia exports 60 per cent of the world's traded wool, the price is influenced by not only the world wool supply, but also by the supply of substitute fibres, particularly synthetics. Income growth and changes in consumer preferences affect the demand for woollen apparel, and thereby the world price for wool.

Despite being price takers, there are opportunities for Australia to export to markets where demand for agricultural products is strong and relatively accessible (because of proximity and favourable import policies). The opening of markets in developing Asia, with its strong growth in population and income has led to a shift in Australian exports to Asia over the past decade. The share of Australia's agricultural exports to Asia increased from 52 per cent in 2007–08 to 69 per cent in 2016–17. The fastest growing export destinations over this period were China, India, Indonesia, the Philippines, South Korea, and Vietnam.

These global economic and demographic developments, combined with Australia's relatively favourable access to markets, can affect the prices received for Australian agricultural commodities, and the composition of commodity production and exports over time. For example, the increase in Asian food demand is expected to continue over the long term, and lead to price increases for some of Australia's key export commodities relative to other markets. This is expected to support production and exports for Australian beef, milk, sheep meat, and wheat (ABARES 2013).

The prices received for exports are important for Australian income growth and regional economic prosperity. It is estimated that the share of agricultural production exported from 2013–14 to 2015–16 averaged around 70 per cent (Cameron 2017). Some industries in the agricultural sector are more export-oriented than others. From 2013–14 to 2015–16 exports accounted for a relatively large proportion of domestic production of wool (near 100 per cent), cotton lint (100 per cent), pulses (86 per cent), canola (75 per cent) and wheat (71 per cent). The value of horticultural and dairy product exports is increasing rapidly, but these products are mainly sold in the domestic market.

Despite periodic cycles of strong price growth, the long-term trend in nominal agricultural prices has been fairly subdued, and declining in real terms. As a result, producers have relied heavily on on-farm productivity improvements to lift farm incomes and maintain profitability. Moreover, agricultural productivity growth has been positive and increasing faster than most other domestic industries (Campbell & Withers 2017). Since the mid-1990s, the volume of agricultural production has increased at a faster rate than prices. This is largely due to weak growth in the price of grains, as additional supply from emerging countries put downward pressure on international prices. However, price growth has varied significantly across industries. For example, prices have increased in the meat and dairy industries, where growth in external demand is outpacing supply.

This paper aims to introduce a new suite of price and volume indicators that can be used to investigate trends in more detail. For example, which industries have experienced strong growth in international commodity prices, and which industries haven't? How do these prices compare with our export competitors? Has the volume of production and exports responded to changes in relative prices?

2 Existing export price and volume indicators

Agricultural export price and volume indicators are formed when individual data series are compiled into a single index. Indicators are useful for identifying trends and drawing attention to particular issues. They can also be helpful in benchmarking or monitoring performance (OECD 2008).

Before the development of agricultural export price and volume indicators was undertaken, a stocktake of existing Australia-centric indicators was conducted to establish what was publicly available. The compilation of individual data series into an indicator is complex and requires the use of data aggregation techniques to ensure that the resultant index is a true reflection of reality. Therefore in considering the publicly available indicators, it is important to consider how the indexes are constructed. This section briefly outlines the characteristics of the publicly available export price and volume indicators and describes their limitations.

Australian Bureau of Statistics

The Australian Bureau of Statistics (the ABS) publishes a number of quarterly export price and volume indicators. While there is one set of available volume indicators, there are three different sets of price indicators available from the ABS. The price indicators differ in methodology, source data and coverage. A detailed comparison of the export price indexes is available from the ABS (ABS 2012).

Chain volume measures and implicit price deflators

The ABS publishes volume and price indicators for Australian agricultural exports in *Balance of Payments and International Investment Position, Australia (Cat. no. 5302)* (the BOP). The volume indicators are calculated directly and the price indicators are derived from the value and volume. This means these indicators are consistent and can be used to decompose the value of exports into its volume and price components.

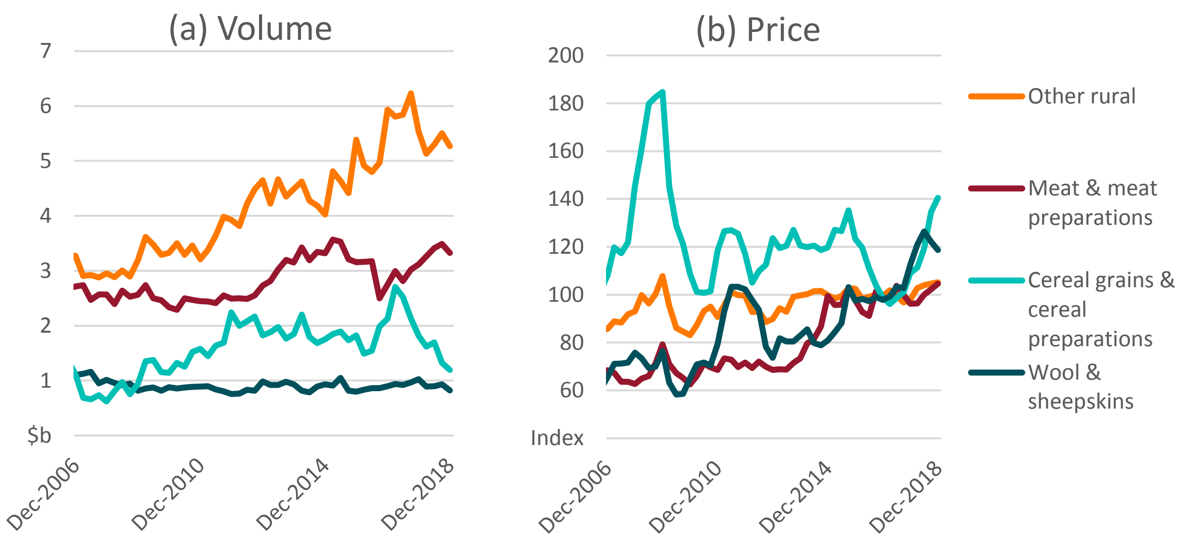
To derive the aggregated export volume indicators, the ABS calculate constant price measures of exports at the 8-digit Australian Harmonised Export Commodity Classification (AHECC) level. The constant price estimates are then aggregated according to BOP classifications using a Laspeyres chaining method. These chain volume measures (CVMs) are expressed in dollars. The chaining ensures that the changes in volume reflect current changes in relative prices of commodities. This is important for commodities that experience rapid changes in prices.

The price indicators are derived by dividing a current price value by its corresponding CVM, and are called implicit price deflators (or IPDs). IPDs are expressed as indexes and show the change in prices over time. Because the CVMs are Laspeyres chain indexes, the derived IPDs are chain Paasche price indexes. Because unit values are used in the calculation, the IPDs do not explicitly control for the qualities of the commodities and, as a result, these price indexes may capture effects of changes in quality (rather than prices) of the commodities. However, because the CVMs are compiled at a very low level (the 8-digit AHECC), these issues are unlikely to significantly diminish the quality of the IPDs.

Agricultural exports in the BOP are classified as *rural goods*. There are also four subindices to rural goods exports, for which IPDs are available (Figure 1). The first two represent Standard International Trade Classification (SITC) division level codes: *meat and meat preparations* and *cereal grains and cereal preparations*. *Wool and sheepskins* represents SITC group level codes and *other rural* represents the sum of select SITC division and group level codes.

Figure 1 (a) charts the chain volume measures of the four components of rural goods exports. These are expressed in 2015–16 Australian dollars. The largest component is other rural at around $6 billion, double the second largest component, *meat and meat preparations*. This level of aggregation is too narrow, because other rural, which represents almost 50% of the total is a meaningless category. This is because it includes many different types of agricultural goods that span different agricultural industries. It is also where most of the growth in agricultural exports is occurring. A breakdown of *other rural* goods would therefore be desirable.

Figure 1 Rural goods volumes and implicit price deflators



Note: Volume indicators are seasonally adjusted chain Laspeyres volume measure, price indicators are seasonally adjusted chain Paasche price indexes, Reference year 2015–16=100. Expressed in Australian dollars.
Source: Australian Bureau of Statistics

Export price indexes

The ABS also publishes annually-reweighted (non-seasonally adjusted) chained Laspeyres price indexes in *International Trade Price Indexes, Australia (cat. no. 6457)*. These are referred to as Export price indexes or EPIs. An EPI is published for the agricultural sector according to the Australian and New Zealand Standard Industrial Classification (ANZSIC). More narrowly defined EPIs that provide additional detail are also produced, including price indexes based on the BOP classification as described above, and specific AHECC section categories. The greater disaggregation available with the EPI make them more useful compared with the IPDs.

The EPIs display different price movements from their counterparts published in the BOP. The main differences are attributable to the underlying concepts, index methodology and data sources used for each index (see Table 2). With regard to data sources, the IPDs are mainly derived from unit values, which are obtained from customs data. EPIs are compiled using a combination of unit values from customs data, secondary sources of price data and prices from surveying representative items from establishments. The latter is the favoured approach. However, the ABS states that *"for items that are homogenous and where quality change is minimal, e.g., basic commodities from the mining and agricultural sectors, it can be more efficient to selectively use average unit values as price estimators. Where index accuracy is not compromised, the use of average unit values reduces cost and respondent burden and, in some cases, provide increased robustness and coverage to price estimation."*

Reserve Bank of Australia

The Reserve Bank of Australia (RBA) publish price indexes, but do not publish complementary volume indicators. This is because the main purpose of the RBA export price indexes is to provide a timely indication of the price movements of the commodities that have a significant bearing on the terms of trade. This assists with the RBAs consideration of monetary policy (Robinson & Wang 2013).

The RBA publishes these price indexes as chain Laspeyres indexes. The rural price index is a subindex in its monthly Index of Commodity Prices (ICP). The ICP is a monthly annually-reweighted index.

The rural component includes indicator prices of Australia's eight largest agricultural export commodities by value (Table 1). These are reviewed on a regular basis, meaning that the composition of the index can change over time as export shares change. The prices used are international spot or futures prices, offer prices from exporters and quotes from Australian saleyard auctions. Refer to Appendix A for more information about the price indicators. The RBA ICP is not affected by changes in the physical good because the indicators are derived from price data of representative goods in each commodity group.

Table 1 Price sources and commodity weights in the rural subdivision of the RBA Index of Commodity Prices

Commodity	Weight (%)	Description
Beef and veal	34.7	Average of beef prices to the United States and Japan
Wheat	21.1	US Gulf price, HRW No 1
Lamb and mutton	10.9	Eastern States Trade Lamb Indicator, MLA
Wool	10.2	National price, Australian Wool Exchange
Sugar	6.8	Sugar No. 11 ICE
Barley	6.1	Confidential
Cotton	5.4	Cotlook A Index
Canola	4.8	Canola Par Region

Note: Weights for each commodity in the rural subindex represent their relative value share of exports. These index weights were updated on 1 April 2017.
Source: Reserve Bank of Australia

Limitations of using ABS and RBA indicators

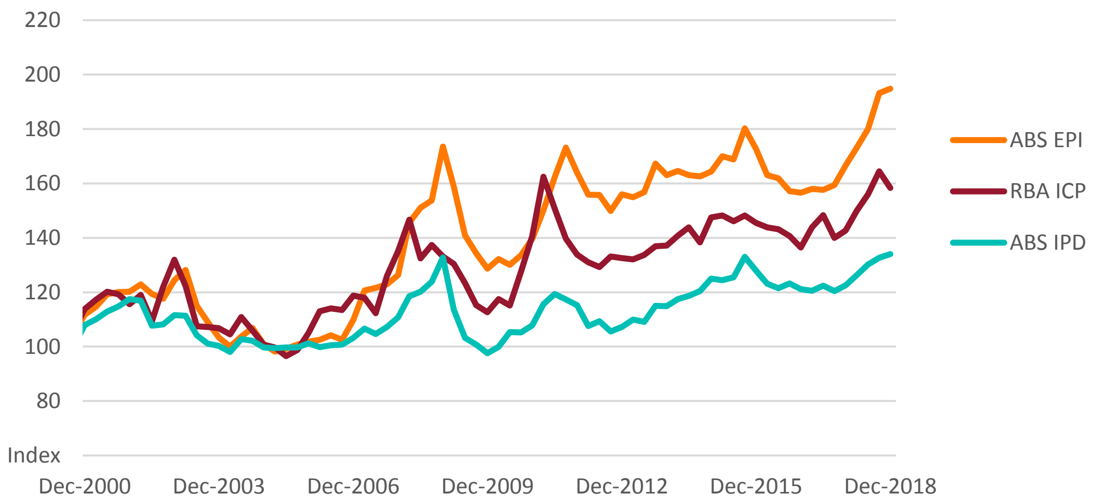
The most important limitation with the ABS and RBA indicators is the lack of subindexes that allow the user to drill-down and explore changes across different commodity groups. Statistics from the ABS and the RBA can only provide a limited view of the broad developments in the Australian agricultural sector.

A related issue is that ABARES uses its own commodity classifications, which differ significantly from the classifications used by the ABS and the RBA. These differences are understandable, given they were constructed for a different purpose. However, the differences limit ABARES' ability to use the publicly available price and volume indicators for analysis.

The RBA ICP is also of limited use for analysis because it does not provide a comprehensive coverage of Australian agriculture, representing about 65 per cent of total agricultural exports. Moreover the composition on the index can change over time. The RBA do not publish complementary volume indicators.

Lastly, the indexing methodologies and source data used for the various price indicators (the ABS IPDs and EPIs and the RBA ICP) differ substantially, making complementary use of these indexes (to cover data gaps) difficult. Figure 2 shows there is significant variability among the different export price measures.

Figure 2 Agricultural export price indexes



Note: The ABS Export Price Index (ABS EPI), RBA Index of Commodity Prices (RBA ICP) and ABS Implicit Price Deflator (ABS IPD) are referenced to 2005 = 100. Indexes expressed in Australian dollars.
Source: Australian Bureau of Statistics; Reserve Bank of Australia

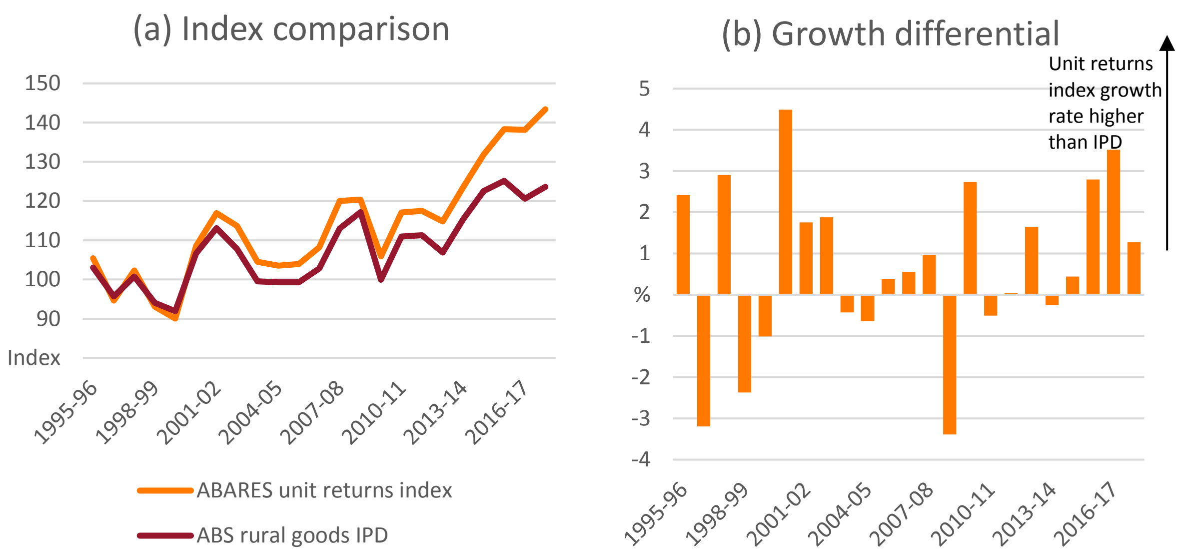
Existing ABARES price and volume indicators

At the time of conducting this review ABARES had available one export price index called the Export unit returns index. This index measures the change in agricultural export prices from year to year. However, there were no volume indicators available. This was in contrast to a greater availability of production volume indicators and unit return indexes that were readily available as part of the Farmers' terms of trade suite of statistics.

The Export unit returns index has an annual frequency and is a weighted average of 30 commodities, including cereals, dairy, industrial crops (wine and cotton), meat, and wool. The annual index is a chained Fisher price index, with a reference year of 1989–90. The index differs slightly from the ABS IPD. The difference can lead to significantly different estimates for price changes, particularly for years where price changes are large (Figure 3). Apart from differences in index methodology, commodity coverage and the level at which chaining/aggregation occurs are likely key reasons for this divergence. The Export unit returns index is an agricultural price index, whereas the ABS IPD includes forestry and fishing products. Moreover, the Export unit returns index excludes horticultural products and a range of miscellaneous products due to difficulties in measuring price changes for very heterogeneous commodity groups. These are included in the ABS IPD via the inclusion of administrative data at the 8-digit level, or via survey methods.

The key limitation of the Export unit returns index is that it only provides a price index for total agricultural exports. There is no breakdown by sector and commodity groups. Moreover, there are no complementary volume indicators that would assist with the decomposition analysis of the value of agricultural exports.

Figure 3 ABARES export unit returns index and the ABS rural goods implicit price deflator



Source: ABARES; Australian Bureau of Statistics

3 Why should ABARES develop price and volume indicators?

ABARES has undertaken this project to investigate the feasibility of producing a comprehensive set of agricultural price and volume indicators to complement its existing commodity classification structure. The approach taken is to apply an accounting framework to develop an 'export account' that would provide value, volume and price statistics according to ABARES commodity export classification. Refer to Appendix B for an overview of ABARES' commodity classifications. This would provide the basis for a tiered structure of price and volume indicators.

This approach is intended to have three distinct, but overlapping benefits. Developing export indicators within a robust framework will deliver a standardised set of indicators that are coherent. This means the indicators are developed in the same way and are comparable. The export account will greatly improve the availability of indicators, laying the foundation for decomposition analysis and new areas of inquiry. The export account is also built in such a way that it can be integrated into the broader reporting framework of ABARES.

Coherence

The brief analysis of the existing publicly available Australia-centric export price and volume indicators demonstrates that there does not exist a comprehensive and standardised set of indicators. The RBA ICP is published monthly but is limited in its commodity coverage and does not include volume indicators. The ABS have available both price and volume indicators of agricultural exports, but the indicators are aggregated into groupings that are too narrow for detailed analysis.

The long-standing ABARES export unit returns index has good coverage but provides limited insight because it is a relatively infrequent headline indicator and does not include subindexes or complementary volume indicators. Another complication that prevents a combined use of available price and volume indicators is the differing source data and index methodologies. Table 2 compares the different methods used to derive the export price indexes.

The export account will provide a standardised set of statistics for analysis according to ABARES classification and reporting of agricultural commodities (Table 2).

Table 2 Comparison of Australian export price indexes

	ABS implicit price deflators	ABS export price indexes	RBA index of commodity prices	ABARES export unit returns index	ABARES proposed indicators
Index	Current weighted Paasche index	Annually weighted chained Laspeyres index	Annually weighted chained Laspeyres index	Annually weighted chained Fisher index	Annually weighted chained Fisher index
Weights	Annual average	Average of the most recent 2 years	Average of the most recent 2 years	Annual average	Annual average
Data source	Derived average unit values	Survey and limited use of average unit values	Indicator prices	Average unit values	Average unit values
Coverage	100%	100%	~65%	~75%	100%
Subindexes	Yes	Yes	No	No	Yes
Frequency	Quarter	Quarter	Month	Annual	Month
Classification	BOP	ANZSIC, BOP, AHECC	Top eight exports by value	ABARES	ABARES

Source: ABARES; Australian Bureau of Statistics; Reserve Bank of Australia

Decomposition analysis

Developing standardised in-house price and volume indicators will also allow analysts to decompose growth in the value of exports into its price and volume contributions. This capability will allow for more in-depth analysis of how Australian agricultural exports are performing.

The difference between real values and volumes

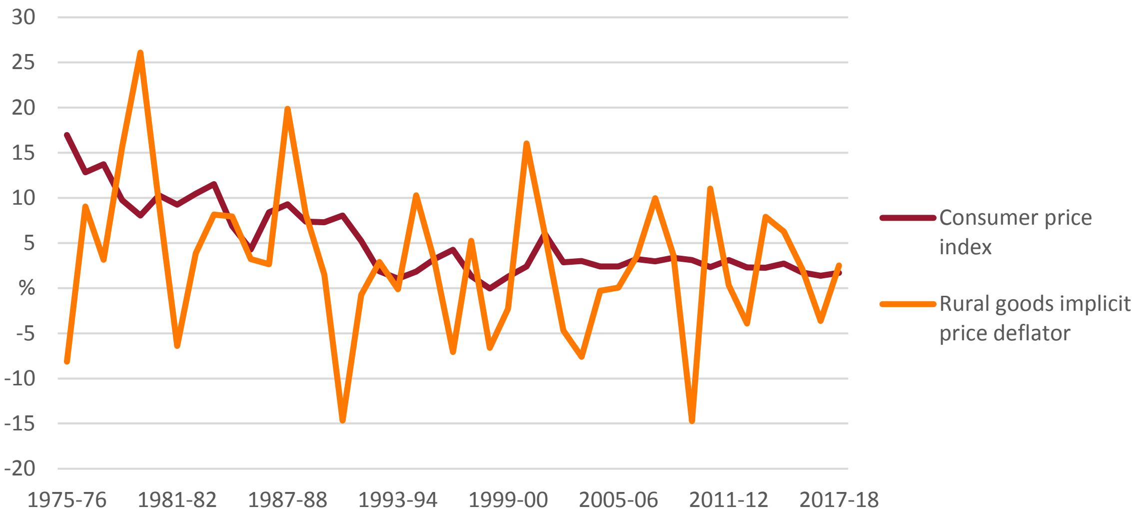
The volume indicators compiled in the new export account differ from real values, which are also reported by ABARES.

Real values refer to the practice of dividing the value of exports by the Consumer Price Index (CPI). Real values provide an estimate of the purchasing power of income because the CPI measures the prices of a wide range of goods and services consumed domestically.

Volume indicators provide analysts with a measure of the physical amount of commodities exported (typically expressed as an index or in dollars). This requires a price index that will strip away the price component of the value of exports to reveal the volume exported.

Figure 4 compares the CPI with an example of a price index called the rural goods implicit price deflator. The Figure shows that the agricultural export prices, represented by the rural goods implicit price deflator, are highly variable relative to the CPI.

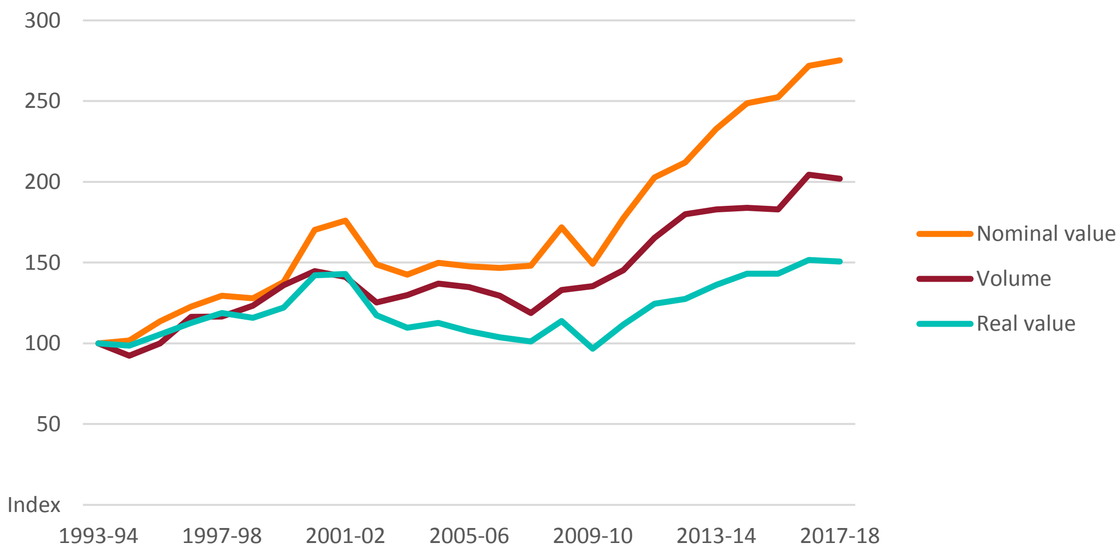
Figure 4 Growth in consumer prices and agricultural export prices



Source: ABARES, Australian Bureau of Statistics

The interpretation of real values and volumes differ. The real value of agricultural exports provides analysts with an understanding of the value of an income stream, called export earnings, in today's dollars. The volume of exports represents how much commodities are exported if we remove changes in prices. Figure 5 provides an example. The real value of agricultural export earnings fell from 2001–02 to 2007–08, whereas the volume of exports remained fairly stable. The real value declined because the growth in average export prices (of about 1 per cent) was much lower than the average growth in CPI over this period (2.9 per cent). This eroded the real value of export earnings.

Figure 5 Nominal, real value and volume measures of agricultural exports



Note: Reference year 1993–94 = 100

Source: ABARES, Australian Bureau of Statistics

Other areas of inquiry

Agricultural export prices and volumes have a number of possible applications.

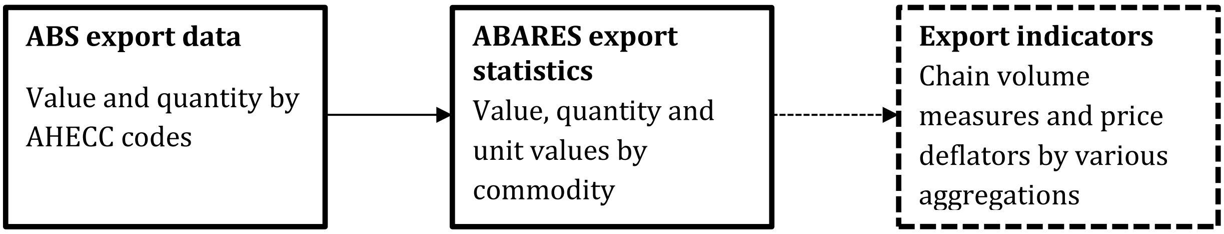
- **They can help in understanding the impact that external forces have on Australian farm income.** The agricultural sector is export oriented, meaning that it is particularly exposed to fluctuations in international commodity prices, exchange rates and country-specific import policies, all of which affect the global competitiveness of the Australian agricultural sector.
- **They can contribute to our understanding of pressures on domestic production arising from changes in global demand.** It is important that the agricultural export price index be divided into sub-categories so that the impact of changes in relative export prices between industries can be assessed. Relative export prices in the agricultural sector are an important indicator of potential structural change.
- **They are useful in the decomposition of export performance to price and quantity effects.** For example, knowing that the value of exports has increased by 5 per cent is not very informative if we do not know how much of this change is due to commodity prices, relative to changes in quantities exported.

To contribute to a broader reporting framework

The set of indicators are intended to complement and build on the nominal value and quantity data that ABARES receives from the ABS.

ABARES receives detailed international merchandise trade (IMT) data from the ABS, and maps that data to conform to ABARES commodity classifications. Currently there is minimal transformation of the data. Figure 6 depicts (in dotted lines) the proposed extension to the use of ABS data.

Figure 6 Current and additional uses of ABS export data



Source: ABARES

The data includes the values and quantities of agricultural commodity exports at the 8-digit AHECC level. This data forms the foundation of ABARES' reporting structure of the nominal value of agricultural commodity exports. The individual 8-digit AHECC codes are grouped by commodity type, and then aggregated into commodity groups and sectors. The final aggregation is total Agriculture. The resulting tree allows for detailed accounting and analysis of the nominal value of Australian agricultural commodity exports (refer to Appendix B).

A motivation for constructing the export price and volume indicators is to leverage the existing IMT data to develop indicators according to the same structure as the nominal value of exports. This accounting framework, constructed according to ABARES' commodity classifications, will allow for detailed analysis of the agricultural sector across multiple areas of enquiry, such as trade, structural change and productivity analysis.

The export account includes both price and volume indexes at monthly, quarterly, and annual frequencies and at various aggregation levels. The export account will:

- consist of a coherent suit of theoretically sound, practically relevant, accurate, and interpretable price and volume indexes
- cover most, if not all, agricultural commodity exports
- be flexible to enable ABARES to produce price and volume indexes for almost any commodity group at various aggregation levels
- enable ABARES to produce and publish the price and volume indexes in a timely and cost-effective way, based on ABARES commodity classifications
- meet a wide variety of needs for modelling and other analytical applications on the issues relating to Australia's agricultural export and rural economy.

4 Measuring prices and volumes

The first thing to consider when developing export price and volume indicators is the approach to measurement. There are two approaches that can be taken:

- build price indexes and use them as deflators to obtain volume estimates. Because the price indexes are constructed first, they are usually referred to as direct measures of price change. The estimates for volume are a residual and are therefore an indirect measure of volume change.
- the alternative is to first construct volume indexes and use these to derive price indexes. According to this approach prices are the residual and are referred to as implicit price deflators.

This paper takes the former approach, which is usual practice. The advantage of constructing direct price indexes is the greater availability of price data. Moreover, price data is generally less volatile than quantities at high frequencies. This means it is more likely that measurement issues can be overcome. Therefore the focus of this chapter will be on the different price measures available for constructing direct price indexes. In Chapter 5 and Chapter 6 the focus will be on price index methodology given that volume will be derived as a residual.

Measures of price

A key consideration for developing these indictors was to leverage from existing detailed merchandise trade data to build a coherent framework of export indicators, and improve analysis.

The implication of this decision is that export prices would need to be measured using unit values. The literature notes concerns about the use of unit values, however, an argument for their use is provided below. Moreover this is a cheap and effective solution because ABARES already uses these data for reporting, analysis and forecasting. Use of these data would therefore maintain conceptual consistency between the new export account and current practices. Ultimately the new price and volume indicators will be integrated into the broader framework of ABARES holdings of data and statistics.

This section also describes the other available price indicators that are available and the advantages and disadvantages of each.

Unit values

A unit value is a measure of price that is derived by dividing the total value of shipments of a commodity by the corresponding total quantity. Unit values are generally composed at a detailed level and compiled with other unit values into an index using an index formula.

Unit value indexes are generally not considered to be a price index but as a surrogate for a price index. This is because the change in a unit value index may include compositional effects in addition to price effects. However, at a detailed level, the use of unit values is considered to be appropriate as a measure of prices for homogenous commodities.

"Unit value indices are suitable indeed they are ideal - for aggregation of price changes of homogenous items" (IMF 2009)

The IMF provides a thorough account of the limitations of unit values as a price measure (IMF 2009). Some of the limitations do not apply to the agricultural export unit values because of the homogenous nature of the commodities and the high quality of the IMT data. Other downsides to the use of unit values are in regard with their ability to signal turning points. This is because unit values are an average price measure. Unit values generally lag other price indexes that use spot prices or futures prices. Moreover, IMT data may be revised up to six months after the end of the reference quarter (ABS 2012).

The advantages of using unit values include:

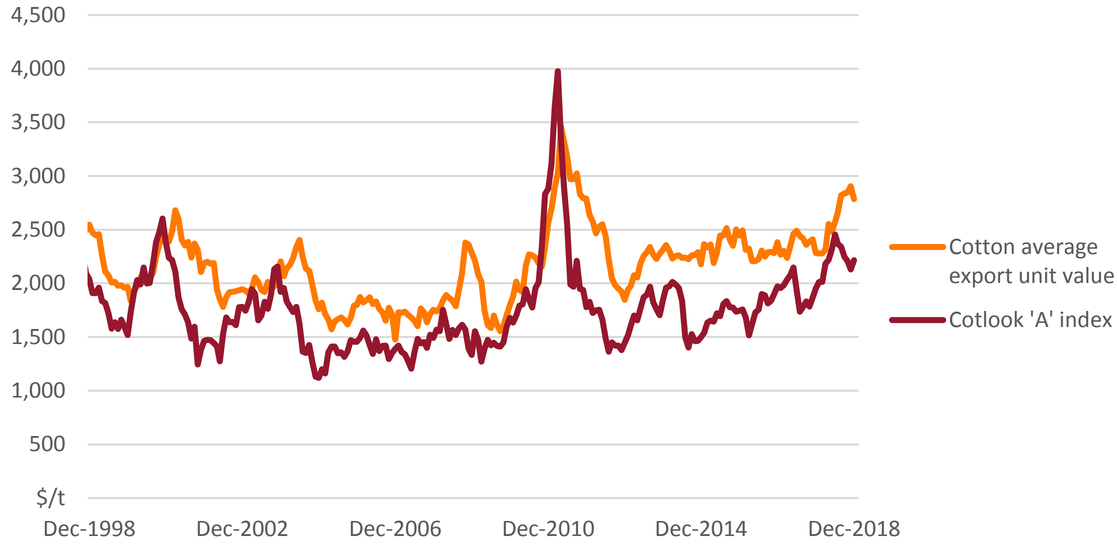
- Significant commodity coverage, since good quality price and quantity data are available for most agricultural commodities.
- Compared to indicator prices, they are a more accurate measure of prices received by Australian exporters. "It should be evident that a unit value for the commodity provides a more accurate summary of an average transaction price than an isolated price quotation" (Diewert 1995).
- Suited for most agricultural products, because they are typically clearly defined and of standard quality.
- The ability to leverage the existing IMT data that ABARES obtains from the ABS.

Indicator prices

Most agricultural price indexes that are available are constructed to represent the change in global prices. Examples include the commodity price indexes produced by the International Monetary Fund and the World Bank, and the food price index produced by the Food and Agriculture Organization of the United Nations. These indexes use global benchmark prices, which are 'representative' of international prices because they are usually selected on the basis of the largest exporter of a given commodity. For example, the Cotlook A index is regarded as the international price of raw cotton. It measures the average price of five of the cheapest cotton varieties exported to the East Asia (Cotlook 2018).

The purpose of global benchmark prices is to help monitor developments in international commodity markets. Such developments can significantly influence prices for Australian agricultural exports. However, the use of global benchmark prices do not align with the purpose of the ABARES export price index, which is concerned with measuring actual prices received by Australian agricultural exporters. For example, Australian cotton is of a higher grade. Therefore prices received by Australian exporters are higher than the global benchmark price (Figure 7).

Figure 7 Global benchmark indicator price and Australian export unit value for cotton



Source: ABARES; Australian Bureau of Statistics; Cotlook

World indicator prices of Australian commodity exports provide an option for price measurement. Some are already used as global benchmark prices because of Australia's presence in those markets. However, the commodity price that is chosen is usually only 'representative' of a subset of the commodity whose price it measures. This is because the quoted price might be for a specific market and for a particular grade or product of the commodity in question. An example of this is the US 90 per cent Chemical Lean indicator price, which could be used as an indicator price for Australian beef, but only represents one-market (the United States) and one grade of meat (90CL).

The reasons for not using indicator prices for the construction of the ABARES export price index are as follows.

- It is difficult to build a comprehensive index of indicator prices alone (perhaps a hybrid could be used) because many smaller and more heterogeneous agricultural commodities, such as wine, may not have indicator prices.
- Indicator prices generally do not reflect the actual return to Australian exporters of the goods that are actually shipped. This is because the quoted price might be for a specific market and for a particular grade of the commodity in question. This is more appropriately measured by the use of average export unit values or a 'representative' set of survey prices. Appendix C compares export unit values to their relevant indicator prices.
- Some indicator prices are only approximate measures of export prices. For example, the lamb trade indicator is a saleyard price which is too early in the supply chain to be considered a true export price indicator. The price relates to the animal not to the meat that is exported.
- Each indicator price is measured differently. Spot and futures prices are used. Some include the cost of insurance, freight or both. Some are weighted average indexes of many products and/or grades. The user needs to be aware of the non-standardised nature of the prices that underlie indicator prices.

Refer to Appendix E for a demonstration of the difference between price indexes compiled with unit values and indicator prices.

Survey prices

Survey prices involve the collection of prices for a representative basket of goods by surveying establishments on a regular basis. The characteristics of products that are surveyed are fully defined so that when the quality or specifications of an item being priced changes over time, adjustments can be made to the reported prices so that the index only captures pure price changes.

The use of establishment price survey data is often compared with the use of customs data to compile unit values. The consensus from the international community of users and compilers of price indexes is for the use of price survey data as the preferred measure (IMF 2009). However, attention is increasingly turning to the use of transactions data for the compilation of consumer price indexes (Diewert & Fox 2017).

The IMF Export and Import Price Index Manual states that the preference for price survey indexes was, in large part, due to a potential bias in unit value indexes mainly attributed to changes in the mix of the heterogeneous items recorded in customs documents (IMF 2009). The manual further states that unit value indexes are not very useful for modern product markets given the increasing differentiation of products and turnover of differentiated products. However, it is also acknowledged that the use of unit values is appropriate for homogenous products. This criterion can be satisfied for many agricultural products, provided the level of disaggregation is low enough.

The ABS found that survey data can provide a more accurate estimate of price change significantly earlier than is possible with unit value data, due to the propensity for the latest six months of customs data to be revised (ABS 2012). The ABS compiles prices for many agricultural commodities using a combination of survey prices and customs data. This is because many agricultural commodities are homogenous, and because of the high detail and quality of Australian customs data.

The use of survey prices is not realistic for ABARES because the cost of gathering these data would be prohibitive. Another limiting factor is that survey prices are not available on a monthly basis.

Index frequency

Another consideration in constructing export price indexes is the length of the period-to-period intervals. Referred to as the frequency, indexes are often constructed on a monthly, quarterly or annual basis.

The frequency chosen should align with the purpose of the index. For example, the RBA Index of Commodity Prices is published monthly, with the purpose of providing a timely indication of movements in the price of major Australian commodity exports. The ABS publishes export price indexes on a quarterly basis rather than a monthly basis. This is because the main purpose of the indexes are to support the compilation and analysis of the quarterly macroeconomic statistics.

An objective of this paper is to develop monthly export price indexes. Monthly indexes are important because agricultural prices are volatile and can change rapidly in a short period of time. A higher frequency index is therefore required to monitor these changes.

The compiler also needs to be cognisant of the challenges associated with constructing a high frequency index. These challenges are considered in Chapter 8 of the paper, and include issues such as seasonality, chaining, and the weighting procedure.

Quarterly and annual indexes are also constructed. A quarterly index would be useful for economic analysis as many economic indicators such as inflation are available on a quarterly basis. The annual index is important because it allows the indexes to be integrated into ABARES' forecasting framework.

To avoid introducing upward or downward bias in the results of these lower frequency indexes, the unit values that underlie the indexes will be constructed over the same period as the index in question (Diewert, Fox, and Haan 2016). Therefore, the quarterly and annual indexes are not simply aggregations of the monthly index, but rather a recompilation of the indexes using quarterly and annual data respectively.

5 Index theory and methodology

Because prices are measured directly, this section focuses on the measurement of price indexes. The attributes required to derive volume indicators are also considered.

Price indexes are constructed to summarise a vast amount of information into a smaller set of numbers. They are conducive to observing key trends in the average price received for a large group of goods and/or services that are traded. An agricultural export price index is intended to measure the movements in the weighted average price for a range of agricultural products sold on the international market.

Two important issues need to be considered when constructing price indexes. The first is choosing an appropriate index formula. This is not a trivial task. Dozens of formulae have been proposed, each with distinct statistical properties and economic interpretations. However, in this paper analysis is confined to three of the more popular indexes. The second issue is concerned with applying a chaining method to form a time series index over an extended period of time.

Index formula

The change in the average prices of agricultural commodity exports cannot be directly observed over time. They must be estimated using a formula that compiles actual price observations into a price index. This paper considers the merit of three of the most commonly used index formula: the Laspeyres, Paasche and Fisher indexes.

The Laspeyres index (Equation 1) is widely used to construct export price indexes. The most commonly cited reason for its use is its ease of interpretation and low data requirements. This is because the only change that is occurring period to period is confined to the ratio of prices. The weights remain fixed at some base period.

Laspeyres Index: $$L_t = \frac{\sum_i p_{it} q_{io}}{\sum_i p_{io} q_{io}} = \frac{\sum_i v_{io}(p_{it}/p_{io})}{\sum_i v_{io}} = \sum_i w_{i0}(p_{it}/p_{i0}) \quad (1)$$

This formula generates an index number (L_t) for the weighted average of the prices observed in the comparison period (denoted as t), relative to the prices in the base period (denoted as *0*). In this formula, p_{i0} and q_{i0} represent the price and quantity, respectively, of the ith export commodity observed in the base period; p_{it} and q_{it} are the price and quantity of the commodity in the comparison period; $\sum_i v_{i0}$ is the total export value of the commodities included in the calculation in the base period; w_{i0} is the share of the total export value of the ith commodity in the base period. Equation (1) shows that the Laspeyres index can be expressed in alternative ways that are mathematically equivalent. The first is the ratio of the values of the basket of export commodities in the base period when valued at the prices of the comparison and base periods respectively. The second is a weighted arithmetic average of the ratios of the individual prices in the comparison and base periods using the shares of the total export value in the base period as weights. Essentially the Laspeyres index measures the weighted average of changes in prices (p_{it}/p_{i0}) using export quantities or transaction values in the base period as the weights.

The second index formula considered is the Paasche index (Equation 2).

Paasche Index $$P_t = \frac{\sum_i p_{it} q_{it}}{\sum_i p_{i0} q_{it}} = \frac{\sum_i v_{it}}{\sum_i v_{it} (p_{i0}/p_{it})} = \{\sum_i w_{it} (p_{i0}/p_{it})\}^{-1} \qquad (2)$$

This index differs from the Laspeyres index in that changes in prices are evaluated based on the export quantities or transaction values in the *comparison* period, rather than the base period.

The Laspeyres and Paasche indexes are equally valid, but will give different answers, especially when the indexes are constructed over an extended period of time. This is because each index formula uses weights at different periods. In these circumstances, it seems reasonable to take a symmetric average of the two indices rather than relying exclusively on the weights of only one of the two periods.

The Fisher price index (Equation 3) is the geometric mean of the Laspeyres and Paasche indexes, and is one of the most widely used symmetric indexes. This index not only has a strong economic backing (Diewert 1976) but also has important statistical properties (Fisher 1922) (Diewert 1995) (Balk 1995).

Fisher Index $$F_t = (L_t P_t)^{\frac{1}{2}} \qquad (3)$$

The Fisher index is adopted as the agricultural export commodity price index for a number of reasons. First, this index does not suffer the substitution bias associated with Laspeyres and Paasche indexes (Diewert 1976). Second, it has proven to be capable of representing a wide range of production technologies used in agricultural production (Diewert 1995). Thirdly, the Fisher index satisfies some important "statistical" requirements (or axioms) deemed to be important for a price index of Australian agricultural export commodities. Finally, utilising the Fisher index maintains consistency with other indexes published by ABARES.

Economic fundamentals of price indexes

Analysis of price indexes are usually approached via two methods—analysis can focus on technical properties of indexes and what desirable characteristics should be present in indexes (the axiomatic approach) or analysis can focus on the economic interpretation of index formula (the economic approach). The economic approach assumes that prices and quantities are related according to some functional relationship. In the case of the Fisher index, the price index is economically related to a quantity index through a quadratic production function.

A well-known result in index number theory is that if price and quantity are inversely correlated, then the Laspeyres index exceeds the Paasche index. Conversely, if price and quantity changes are *positively* correlated, then the Paasche index exceeds the Laspeyres index (IMF 2009). The economic approach helps to explain the intuition behind this, and provides a justification for the use of a symmetric index.

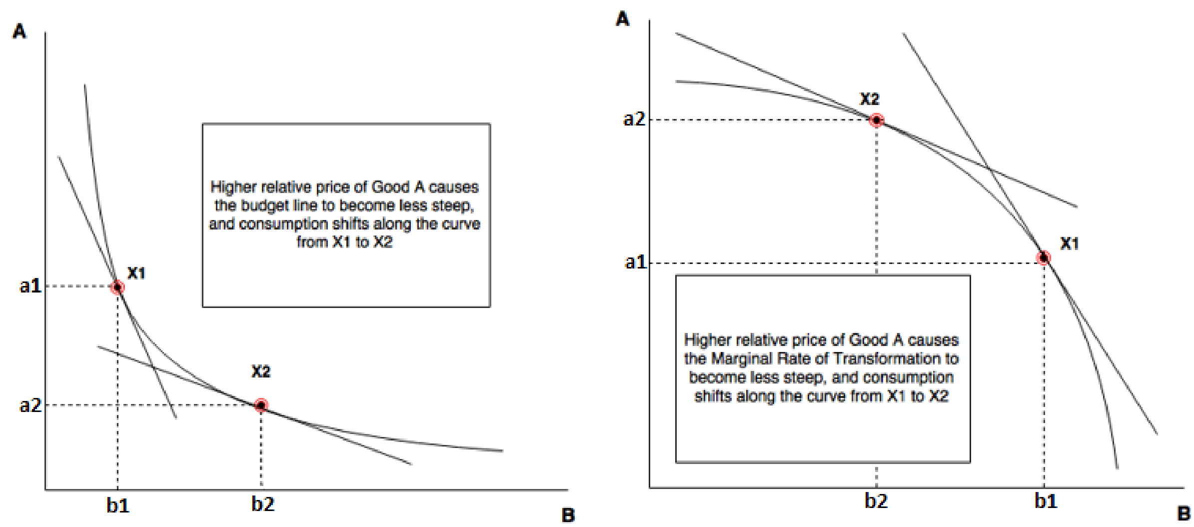
Understanding the interaction between the Laspeyres and Paasche Indexes

As previously discussed, the Laspeyres index uses weights fixed to the base period, whilst the Paasche index uses the weights available in the current period. Given the differences in the weights used, there will inevitably be differences in the values of both price indexes. However, the relative values of the Laspeyres and Paasche indexes can provide insights into the underlying characteristics of the market.

Figure 8 panel (a) shows a scenario where price and quantity are inversely related. This type of relation is typically displayed in the market of consumer goods where consumers shift their consumption away from the more expensive good, and towards the cheaper good when relative prices change. For example, consider an economy with two goods – good 'A' and good 'B'. Given a set of prices and preferences, the point at which the indifference curve is tangent to the budget constraint is the point at which the consumer achieves their maximum utility, and therefore reflects the optimal quantities of both good A and B being consumed. When the price of good A increases relative to good B to become relatively more expensive, the budget line becomes flatter, reflecting the inability of consumers to purchase the same quantity of good A with the same level of income. Consequently, consumers shift their preferences to consume less of good A and more of good B and maximise their utility at the point x_2. Under this scenario, the Laspeyres index runs higher than the Paasche index. This is because the Laspeyres index assumes that at time t, consumption is occurring at the point x_1, when in fact consumption has moved to point x_2, as the Laspeyres weights are fixed in the base period. The opposite is true for the Paasche index, which assumes that for the entire period, consumption has occurred at the point x_2, when in fact consumption had previously occurred at the point x_1. Therefore, we observe that the Laspeyres index tends to overestimate the true price level, whereas the Paasche index tends to underestimate it, causing divergences between the two indexes.

Figure 8 Behaviour of consumer and producer markets to changes in relative prices

(a) Utility maximising consumer (b) Revenue maximising firm



Source: ABARES

The theory of the firm indicates the opposite behaviour on the part of suppliers of goods and services (IMF 2009). In these markets we expect to observe a positive relationship between price and quantity. Producers maximise their revenue by producing at the point where the marginal rate of transformation equates the relative price of the two goods.[1] In Figure 8 panel (b) this occurs at x_1. Now suppose that the price of good A increases relative to the price of good B. This causes production to shift to x_2, where the firm produces more of good A. Because a Laspeyres price index uses fixed weights in the base year, it tends to ignore the substitution of production toward commodities with higher relative prices. The index will thus understate aggregate price changes. On the other hand, the Paasche price index tends to overstate the aggregate price change because it uses the comparison period as weights and ignores the initial revenue shares in the base period.

In reality, movements in commodity prices are often positively and negatively related to the quantities supplied. Some examples of when the relationship between price and quantity can be negative include: circumstances where demand is more influential in the determination of market equilibrium prices (IMF 2004); when a fall in market prices is induced by technological progress (IMF 2004); and, when variable seasonal conditions create uncertainty in the production and supply of agricultural commodities. For both the consumer and producer examples, the true price index lies somewhere between the Laspeyres and Paasche indexes.[2] Therefore, the economic interpretation can be very powerful—it not only establishes an economic argument which underpins the substitution bias in Laspeyres and Paasche indexes but also provides a guiding principal for overcoming substitution bias.

The Fisher index and its characteristics

Economic properties of the Fisher index

Economic properties of the Fisher index (and other symmetrical indexes) were summarised in a term known as the superlative index (Diewert 1976). When it is applied to the production function to measure the relationship between output and inputs, it is superlative because it is equal to a theoretical price index whose functional form is flexible in the sense that it can approximate an arbitrary production technology to the second order. That is, the technology by which inputs are converted into output quantities and revenue is described in a manner that is likely to be realistic of a wide range of forms. It can be argued that the Fisher index is likely to provide a close approximation to the underlying unknown theoretical export price index and, indeed, it is a much closer approximation than either the Laspeyres or the Paasche indexes can individually achieve. The IMF suggested that the use of the Fisher price index can be justified on

[1] The marginal rate of transformation is defined as the slope of the production possibility frontier (the curve in Figure 8, panel (b)). It measures how many units of good A have to stop being produced in order to produce an extra unit of good B, while keeping constant the use of inputs and technology.

[2] Pollak (1983) proved that, for consumer goods, the Laspeyres price index is an upper bound to the cost of living index evaluated at the base period utility level, while the Paasche price index is the lower bound to the cost-of-living index evaluated at the current period utility level.

the grounds of economic theory and, from a theoretical point of view, it may be impossible to improve on the construction of export price indexes (IMF 2009).

Statistical (or axiomatic) properties of the Fisher index

The axiomatic approach to index numbers seeks to determine the most appropriate formula for an index by specifying a number of axioms or tests that the index ought to satisfy. It throws light on the properties possessed by different kinds of indexes, some of which may not be necessarily intuitive or obvious. Indexes that fail to satisfy certain basic or fundamental axioms, or tests, may be rejected completely. The axiomatic approach is also used to rank indices on the basis of their desirability and fitness for purpose. Axiomatic testing dates back to Fisher (1922) and it was further developed and comprehensively documented by Diewert (1995 and 1999), and Balk (1995). The IMF showed that the Fisher index outperforms all other known index formulae by a large margin and is the only one that satisfies all the nominated 21 axioms (IMF 2009).[3] Therefore, on the grounds of axiomatic testing, the Fisher price index has a strong statistical basis.[4]

It is beyond the scope of this paper to elaborate on the axiomatic properties of the Fisher index. However, it is important to note its properties associated with three axiomatic tests which have a bearing on the interpretation of ABARES' export price indexes and the proposed export account: *factor reversal test*, *consistency in aggregation* and *transitivity*. The factor reversal test requires that the product of the price index and the volume index of the same formula should be equal to the proportionate change in the total value in question. For example, if the prices and quantities in the Laspeyres and Paasche indexes (equations 1 and 2) are interchanged, one would obtain their corresponding volume indexes and, using equation (3), a Fisher volume index. The fact that the Fisher price index satisfies the factor reversal test means that the product of the Fisher price and volume index is numerically identical with the change in the total value of exports.[5] This test is important if we intend to decompose the aggregate value into its

[3] In fact, it has been established in the literature that no index number formula can satisfy "all tests" in some broader sense.

[4] While the Fisher price index has been recommended in this study on the ground of its relatively superior performance in terms of axiomatic texts, this index formula does not necessarily perform better than others if a different criteria is chosen. For example, it can be argued that the Tornqvist index (another superlative index) is a preferred choice based on the economic approach. Unlike the Fisher index, it does not rely on the assumption of linear homogeneity. Empirical studies in the literature have demonstrated that the two indexes are very close numerically. If necessary, it is feasible to apply the Tornqvist index and produce a set of price and volume indexes based on this formula

[5] There is a subtle difference between the factor reversal test and what is known as the "product test". The product test also requires the product on a price index and volume index to equal to the proportional change in the total value but it does not require the two indexes to be of the same formula. Hence it is

price and volume components in a consistent manner. The Fisher index is the only price index to satisfy this and other tests (IMF 2009). Satisfaction with this condition means it is possible to derive the Fisher index of export volume by simply dividing the price index by the total value of exports. The axiomatic property will make it relatively straightforward for ABARES to construct a consistent export account with corresponding price and quantity indicators.

Consistency in aggregation means that if an index is calculated step by step, by aggregating lower-level indexes to obtain indexes at progressively higher levels of aggregation, the same result should be obtained as if the calculation of the aggregate index had been made in one step. It was shown by Diewert (1995 and 1999) and Balk (1995) that the Fisher index is not exactly consistent in aggregation, although both Laspeyres and Paasche indexes are. However, the IMF demonstrated that it is approximately consistent in aggregation in the sense that, numerically, the results from the aggregation process are sufficiently close such that users will not be unduly troubled by any inconsistencies (IMF 2009). This property will enable ABARES to develop a suite of price and quantity indexes at different levels of aggregation with any chosen group of commodities.

Table 3 Key properties of index formulae

	Laspeyres	**Paashce**	**Fisher**
Consistency in aggregation	Y	Y	A
Factor reversal test	N	N	Y
Transitivity	N	N	A
Superlative	N	N	Y
Symmetric	N	N	Y
Weights sum to unity	Y	Y	Y

Note: Y indicates that the price index formula satisfies this property, N indicates the formula does not satisfy the property, while an A indicates the formula approximately satisfies the property.
Source: (ABS 1996)

considered as a weaker version of the factor reversal test. A volume index can always be obtained by dividing the total value by a price index (of any formula) and, in this practice, product test is automatically satisfied. But the resulting volume and price indexes are expressed by different formulas. This is unless the price index passes the factor reversal test. For example, dividing the total value by the Laspeyres price index would generate a Paasche volume index. As the Fisher index satisfies the factor reversal test, a Fisher volume index will be obtained by dividing the total value by the Fisher price index.

Chaining of price indexes

The Fisher price index (Equation 3) relates prices between two periods (base period *0* and current period *t*). When the index extends to three or more periods a chained Fisher index can be calculated. The direct index simply measures the difference between the fixed base period *0* and period *t*. In a chained index, the current period is compared to the previous period for all observations, rather than comparing each period to the base period. For example, when a Fisher index is calculated between periods 0 and 2, the direct index is calculated as shown in Equation (4):

Direct Fisher index $$F_{02}^{D} = (L_{02}P_{02})^{\frac{1}{2}} \tag{4}$$

The chained index is calculated as:

Chained Fisher index $$F_{02}^{C} = (L_{01}P_{01})^{\frac{1}{2}} \times (L_{12}P_{12})^{\frac{1}{2}} \tag{5}$$

where L_{02}, and P_{02} are Laspeyres and Paasche indexes, respectively, between periods *0* and *2*, L_{01} and P_{01} are the two indexes respectively between periods *0* and *1*; L_{12} and P_{12} are the indexes between periods *1* and *2*, respectively.

Conceptually, direct and chained indexes measure the same thing, but are likely to provide different values for the change between periods *0* and *2*. Equation 5 relates to an index that is chained together every period. Alternatively, the indexes can be linked together on a less frequent basis. Chained indexes are preferred by analysts for several reasons (Zhao, Sheng, & Gray 2012). It is clear from Equation (4) that as the current period moves further away from the base period (*0*) the weights used to calculate L_{02} may become increasingly less relevant to the current situation. This becomes important in indexes measured over long time periods, as the weights in period t may become significantly different to the weights in the base period.

If the price movements of individual commodities are smooth, chaining can also reduce the gap between the Laspeyres and Paasche indexes, and the chained Fisher index has a better chance of representing the true price index. However, if there are substantial fluctuations in the prices and quantities in the intervening periods, chaining may not only increase (rather than reduce) the index number spread but also distort the measure of the overall change between the first and last periods. For example, suppose all export prices in the last period return to their initial levels in the initial period *0*. A chained Fisher export price index does not return to 100 (i.e. the normalised starting value in the base period). Instead, the index will diverge away from the normalised starting value. If the cycle is repeated, with all the prices periodically returning to their original levels, a chained Fisher index will tend to drift further away from 100, even though there may be no long-term upward trend in the prices. Frequent chaining is therefore not advisable when prices fluctuate widely, particularly when Laspeyres or Paasche formulae are used.

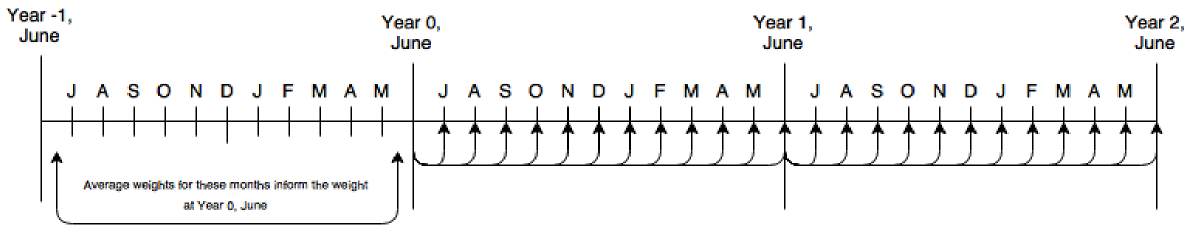
An index that does not drift is said to be transitive, meaning that that the chained index is identical with the corresponding direct counterpart. Unfortunately, the Fisher index does not pass the *transitivity test* (also known as circularity test (Walsh 1921) or *multiperiod identity test* (Diewert 1993), though it may be considered as approximately transitive.

6 Indexing approach

While Chapter 5 provided a theoretical basis for adopting a Fisher formula to produce price indexes, this chapter describes how the Fisher formula is implemented.

The monthly agricultural export price index is an annually reweighted and chained Fisher index. The actual calculation involves two modifications.[6]

Figure 9 Annual chain linking, one-month overlap method



Source: ABARES

The first modification is about the construction of weights for the calculation of both the Laspeyres and Paasche indexes. For the Laspeyres index, the average values of the commodities over the 12 months in the previous financial year are used in the construction of weights. For example, in the calculation of the Lasypeyres price index for July in year 0 (which compares the prices in this month with those in June in the same year), average values over the entire period from July in year (-1) to June in year 0 are used. This set of weights are used in the calculation of the Lasperyes index for all the months from July in year 0 to June in year 1. The weights are updated when the index for July in year 1 is calculated.

However, the weights of the Paasche index are slightly different. They are calculated using the average values over a 12 month "window", which shifts forward as the index progresses over time. Using the previous example, the calculation of the Paasche price index for July in year 0 will take the average values over the period from August in year (-1) to July in year 0. When the index for August is calculated, values for the following 12 months (from September in year (-1) to August in year 0) are used.

The second modification is about achieving consistency with the annual export price index. As discussed earlier, ABARES plans to construct a coherent export account which consists of price and volume indexes at monthly, quarterly and annual frequencies and at various aggregation levels (detailed in Appendix B).

An annually chained Fisher formula (Equation 5) is used in the construction of an annual price index. However, values of monthly and annual price indexes are unlikely to be identical. The

[6] The two modifications are applicable to the quarterly price index where the only difference is that the measurement unit is one quarter, instead of one month.

existence of persistent discrepancies between the monthly and annual price indexes is not desirable because they may cause confusion among users. It is therefore important to achieve a reasonable degree of coherence between the price indexes. It is particularly important that these indexes should not diverge significantly. To achieve coherence, we propose to use the annual price index as the benchmark for the monthly price index and all other (price and volume) indexes in the export account.

Quarterly price indexes have also been developed using the same methodology as the monthly price index. The index is again an annually chained and weighted Fisher price index. The last quarter of a given financial year (June quarter) is the chain base for the next financial year. For example, data for 2017–18 are linked onto the June quarter 2017 value. To calculate the quarterly indexes the underlying unit value data is converted into a quarterly frequency before applying the indexing formula (Diewert Fox & Haan 2016).

7 Results

Monthly indicators

The monthly price index shows that agricultural export prices have increased by around 32 per cent from 1989–90 to 2017–18. To put this into perspective, Australian domestic inflation increased by 94 per cent over the same period, meaning average agricultural export prices have declined substantially in real terms. Note that the reference year has a significant influence on the index level over time.

From a short-term perspective, the monthly index is able to reveal periods of price volatility, with peaks and troughs appearing regularly. A notable example is the food price crisis of 2007 and 2008, where export prices (in Australian dollars) increased rapidly in 2008, and retraced just as rapidly in the following year. Other periods of volatility occurred in the late 1990s and early 2000s. The high frequency of the index will assist with monitoring these sudden changes in average export prices. While the Reserve Bank of Australia publishes a monthly index, it only captures the eight largest commodities and therefore does not provide a complete picture.

To assist with analysis of the drivers of price changes, the monthly agricultural export price index has also been constructed in US dollars to assist with disentangling the effect of the exchange rate on agricultural export prices (Figure 10). The index also incorporates subindexes covering the spectrum of commodity groups.

Figure 10 Monthly agricultural export price index, by currency

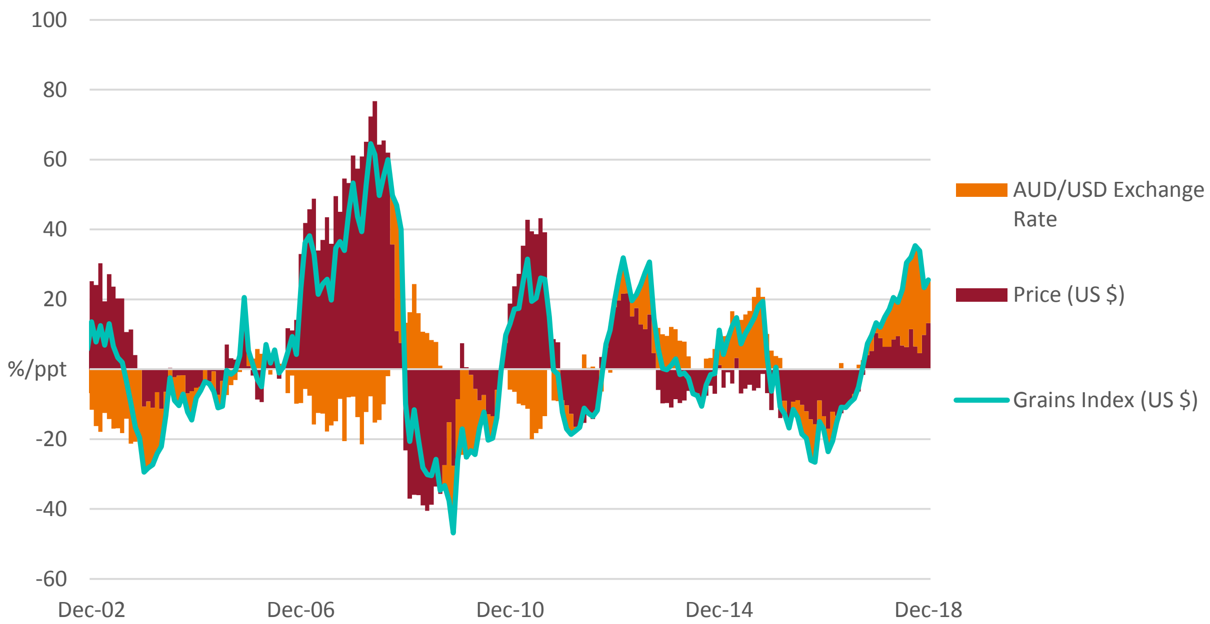
Note: Chained Fisher export price index, June 1989 = 100.
Source: ABARES; Australian Bureau of Statistics

The availability of subindexes and expressed in both Australian and US dollars helps to build a picture of what is driving changes in agricultural export prices. For example, following the food price crisis of 2007 and 2008, there was a gradual increase in average export prices (in Australian dollars), and a plateauing since around mid-2015, before increasing sharply in the second half of 2018. The increase in average export prices was initially led by a depreciation in the Australian dollar from 2013 to 2015, and was supported by strong price growth in livestock and livestock products. The plateauing in the monthly export price index from mid-2015 to the end of 2017 can be explained by the sharp decline in the average export price of crops (particularly wheat) offsetting strong price growth in livestock and livestock products. A decline in the value of the Australian dollar over the second half of 2018 led to another lift in the agricultural export price index.

US dollar exchange rate

The impact of the exchange rate on Australia's average agricultural export prices can be represented by exchange rate contributions to changes in average agricultural export prices. For example, Figure 11 shows the impact that the exchange rate has on the export price index for grains, a subindex of the Agricultural export price index. The depreciation in the Australian dollar over 2013 and 2015 supported growth in Australian agricultural export prices, more than offsetting a decline in US dollar denominated commodity prices. Going further back in time, the appreciation of the Australian dollar during the mining boom was a substantial drag on export price growth. Despite this, strong growth in international grain prices before 2008 boosted Australian dollar denominated export prices. This was briefly disrupted during the global financial crisis, which saw the decline in the Australian dollar cushion the sharp drop in commodity prices.

Figure 11 Contribution to growth of the grains export unit value index



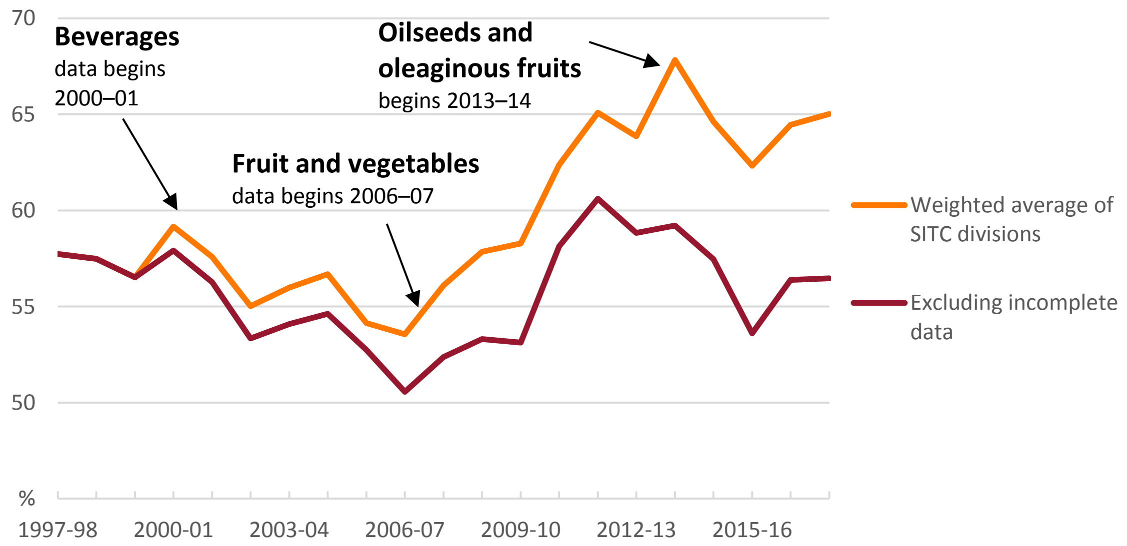
Note: Chained Fisher export price index, June 1989 = 100.
Source: ABARES; Australian Bureau of Statistics

Figure 11 is a useful demonstration of the impact that exchange rates have on Australian export prices. The impact that exchange rates have on Australian agricultural export prices, and thereby its impact on producer and exporter incomes, depends on the currency that the exported good is invoiced in.

The currency that agricultural goods exports are invoiced in varies by industry, but overall a significant proportion of agricultural goods exported are denominated in US dollars (approximately 60 to 65 per cent)[7]. This is particularly true for highly export-oriented industries with homogenous goods that are easily substitutable (Goldberg & Tille 2008). The proportion of Australian agricultural goods denominated in US dollars has also been increasing over time (Figure 12). This has been driven by an increase in the proportion of exports invoiced in US dollars in the textiles, dairy, fruit and vegetables and beverages industries. This trend has been observed across many Australian export markets as Australia becomes more integrated internationally (Dwyer, Kent, & Pease 1993). Typically exportable goods are more likely to be denominated in the local currency (Australian dollars) if they are differentiable and come from industries that are less export-oriented (Goldberg & Tille 2008).

Better understanding of export pricing policies across industries would provide more valuable insights. Unpacking the effect of export pricing policies on average agricultural export prices and the implications for Australian exporters and farmers is another possible avenue of work that could be undertaken with the development of these new export price indexes.

Figure 12 Proportion of Australian agricultural goods exports invoiced in US dollars



Note: The ABS collect invoice currency data by Standard International Trade Classification (SITC) divisions. Complete time series data is available for about 64 per cent of rural goods (which is a Balance of Payments definition of agricultural exports). This includes meat and meat preparations, dairy products and birds' eggs, cereal and cereal preparations and textile fibres and their wastes. Data for beverages begins in 2000–01, fruit and vegetables data is available from 2006–07 and oilseeds and oleaginous fruits is available from 2013–14 (these groups represent another 18 per cent of rural goods exports). Data is available every two years and are linearly interpolated between observations.
Source: ABARES; Australian Bureau of Statistics

Subindexes

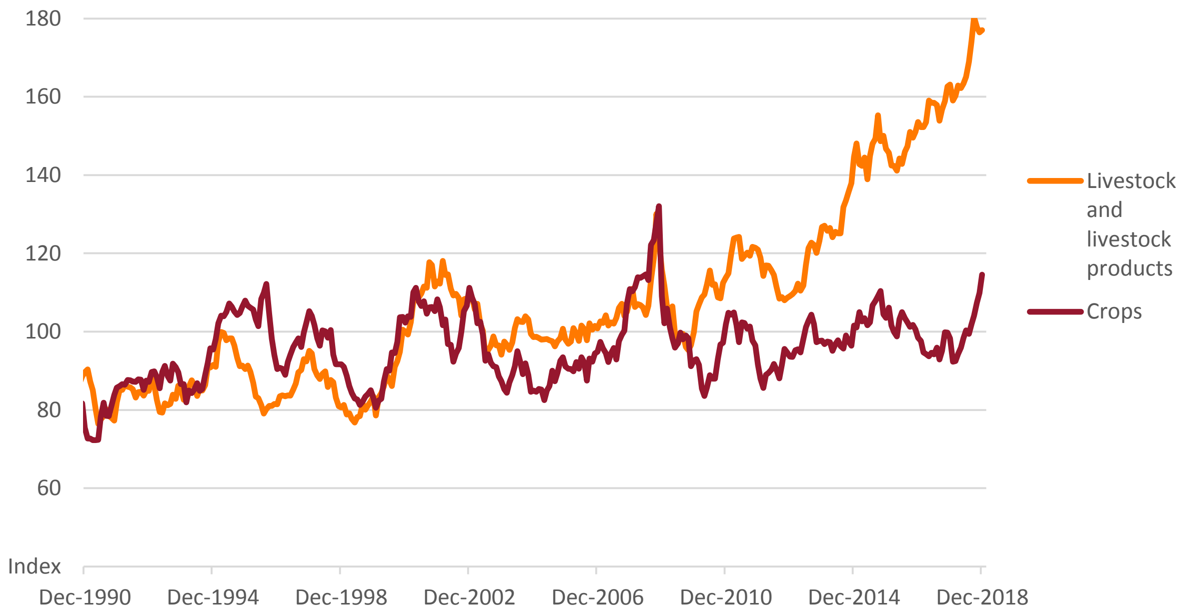
In Chapter 5, it was discussed that the Fisher index is approximately 'consistent in aggregation'. This means that it is possible to build subindexes whose components approximately equal the

[7] This is an estimate based on publicly available data from the ABS.

total movements in the aggregate index. Given this property, we are able to produce subindexes of commodity groups which help to explain the movement in the aggregate index over time.

The monthly agricultural export price index includes nine subindexes (Appendix B). The first layer of indexes are the *livestock & livestock products* and *crops* indexes. These subindexes reveal that the average export price for the crops and livestock & livestock products sectors have generally moved closely together since the 1990s (note: the index starts in 1989). However, the relationship has broken down in recent years. The divergence between the average price for crops and livestock & livestock products began in 2013, with prices increasing in the livestock sector at a much faster pace than in the cropping sector. That divergence widened in 2016 because of sharp declines in the average price for grains, which weighed on the crops index (Figure 13). From 2013 to 2018, the average agricultural export price increased by 20 per cent. Growth was driven by average prices for livestock & livestock products, which increased by 44 per cent over the same period. This compares with a 2.6 per cent increase in the average price of crops.

Figure 13 Monthly agricultural export price indexes, by sector



Note: Fisher export price index, 1989–90 = 100.
Source: ABARES; Australian Bureau of Statistics

The low growth in export prices in the cropping sector was due to a decline in the average price of grains in 2016 and 2017, while the increase in livestock and livestock products was mainly due to an increase in prices for meat, wool and live animals. At this level the indexes can be quite volatile, but they are nevertheless valuable for the flexibility they provide in the periods that can be compared, such as 'year-to-date' analysis. Because of this volatility, a quarterly series of agricultural export prices has been created and is discussed later in this chapter.

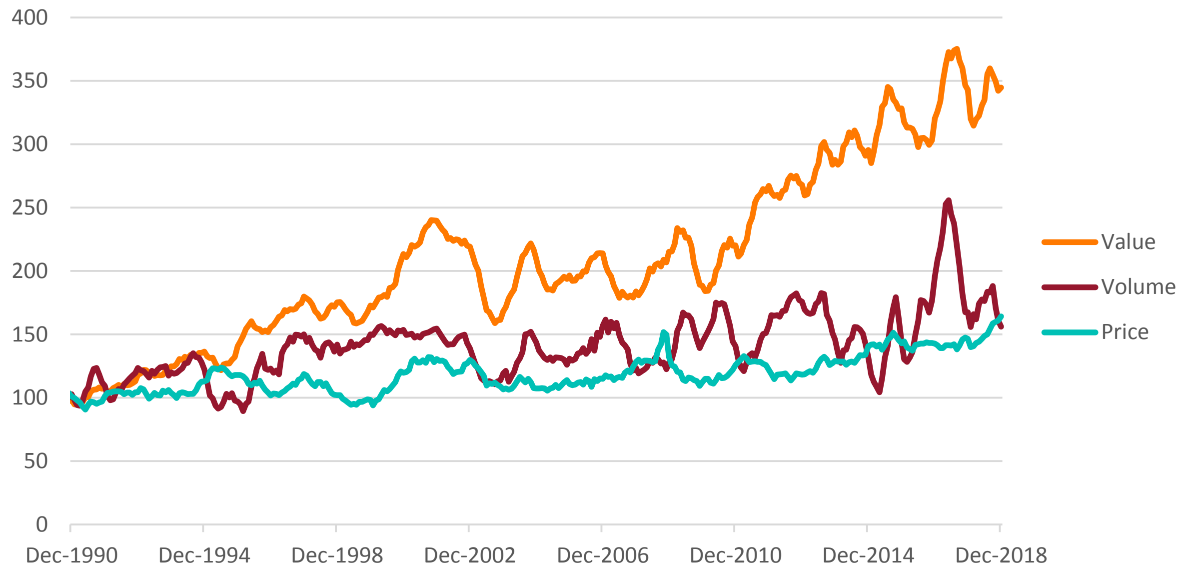
Decomposing value and volume shares

In Chapter 5, it was described that a feature of the Fisher index was that it is satisfies the 'factor reversal' test. That it is to say it is possible to derive the contribution of price and volume.

Figure 14 shows the movement of price, volume, and value of Australian agricultural commodity exports over time. Despite weak price growth over much of the history, the value of exports has increased over time, mainly due to increases in the volume of goods exported. Figure 14 shows that the value and volume indexes have historically maintained a tight relationship, with only small divergences due to periodic price shocks.

Because of the relatively low nominal price growth in agricultural commodities, farmers have sought to improve productivity to increase the profitability of production and exports. The early 1990s and the period following the millennium drought were periods of strong growth in the volume of agricultural goods exported. However, more recently, the value of agricultural goods exported have been driven by prices. This is depicted in Figure 14 by a divergence in the value and the volume indexes since late 2013. This is a unique period in recent history (the past 30 or so years) as it represents the most sustained period in which prices have driven the value of agricultural exports.

Figure 14 Australian agricultural export price, by volume and value

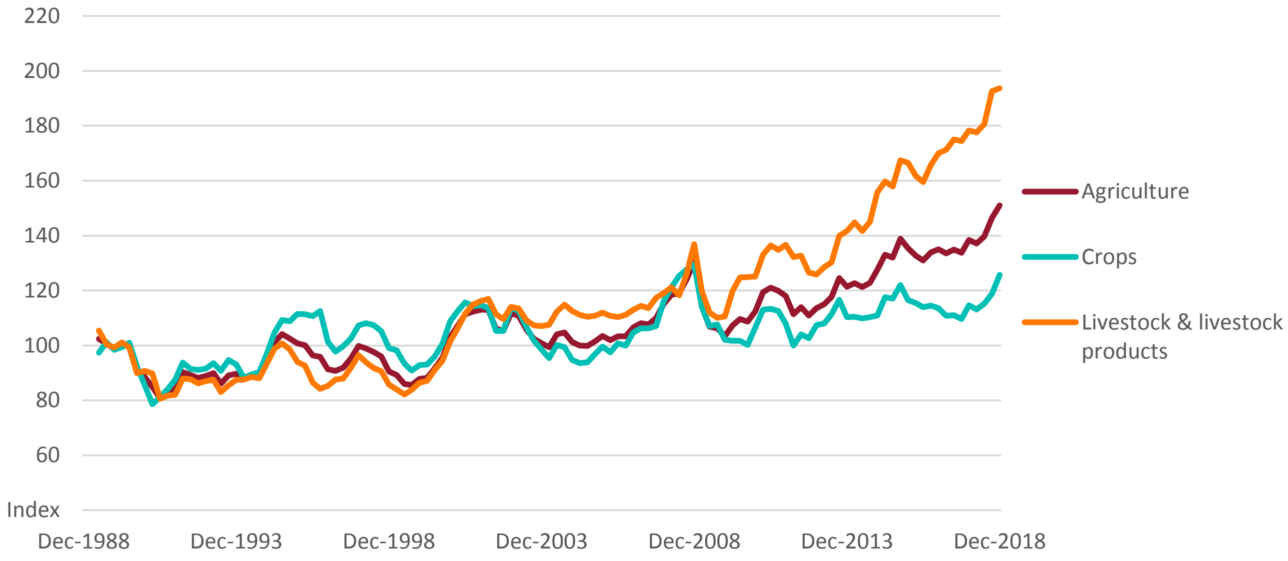


Note: Chained Fisher price and volume indexes, 1990–91 = 100. Indexes are smoothed by applying a 6-month rolling average.
Source: ABARES; Australian Bureau of Statistics

Quarterly indicators

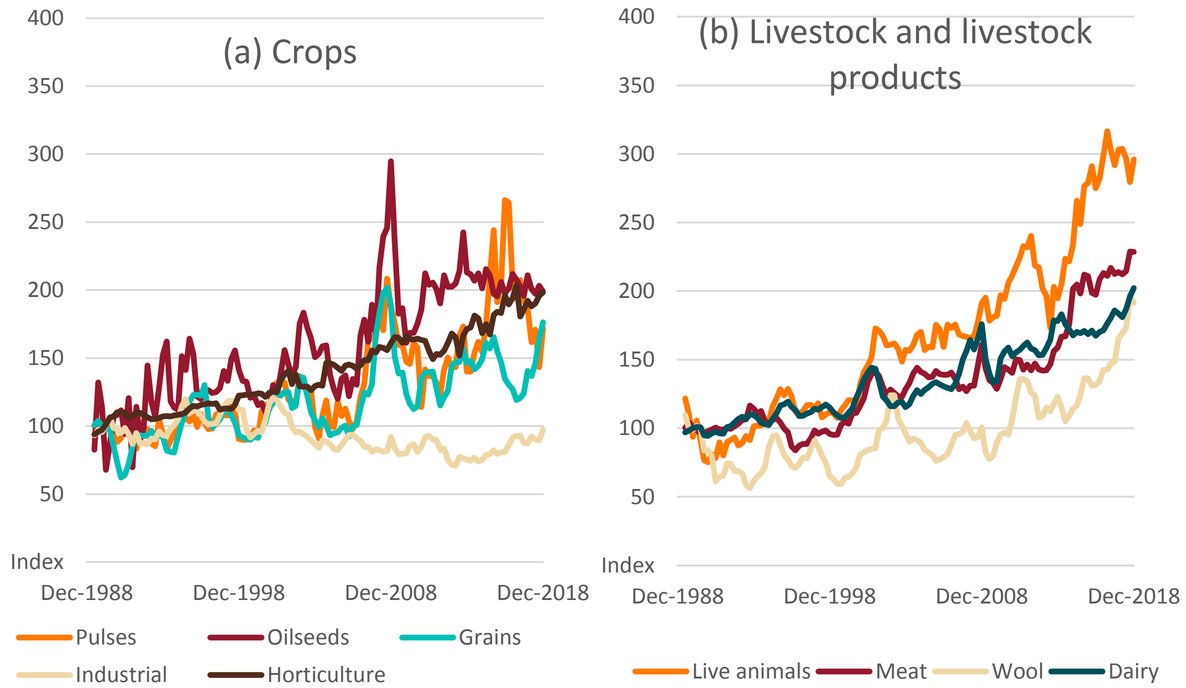
The quarterly indexes are beneficial because they smooth the volatility inherent in the monthly indexes, while they still provide a relatively timely measure of export prices. The quarterly indexes (Figure 15; Figure 16) would likely be useful for analysis with quarterly statistics, such as the trade weighted index and other series from the National Accounts.

Figure 15 Quarterly agricultural export prices, by sector



Note: Chained Fisher price indexes, 1989–90 = 100
Source: ABARES; Australian Bureau of Statistics

Figure 16 Quarterly cropping and livestock sector export price indexes



Note: Chained Fisher price indexes, 1989–90 = 100
Source: ABARES; Australian Bureau of Statistics

Comparisons with ABS price indexes

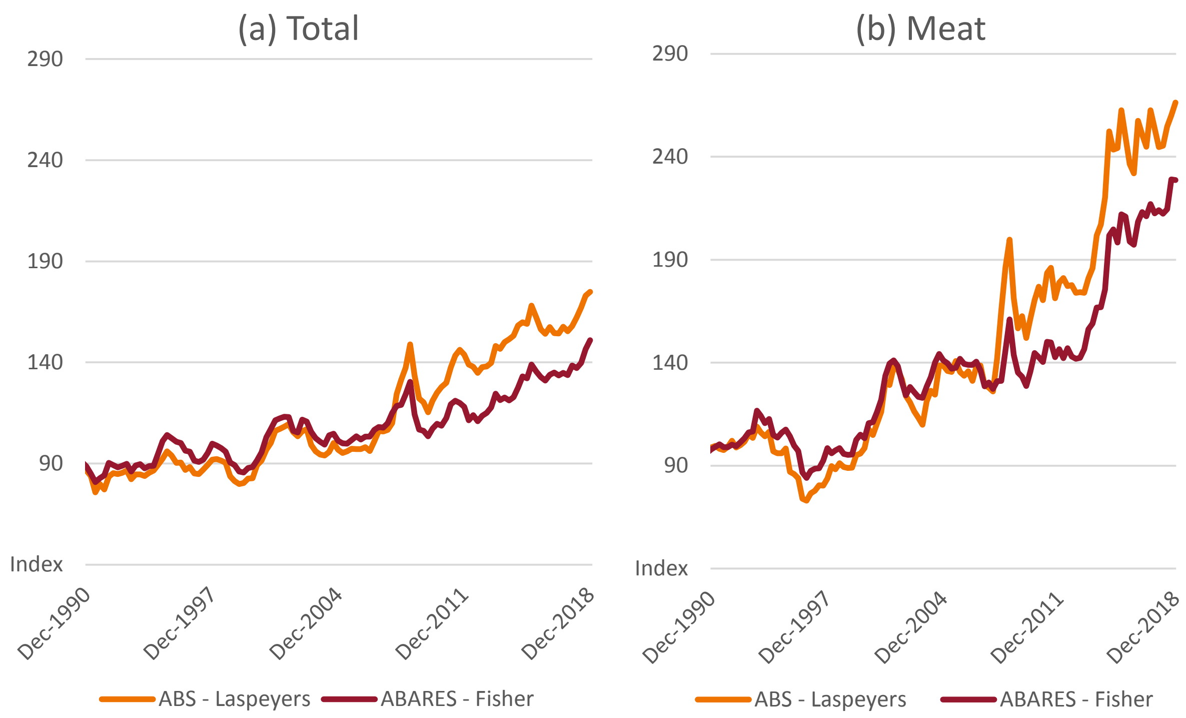
Figure 17 compares the newly constructed ABARES indexes with the ABS Export Price Indexes published in catalogue number 6457.0. Differences arise due to classifications, source data and index methodology used by each agency.

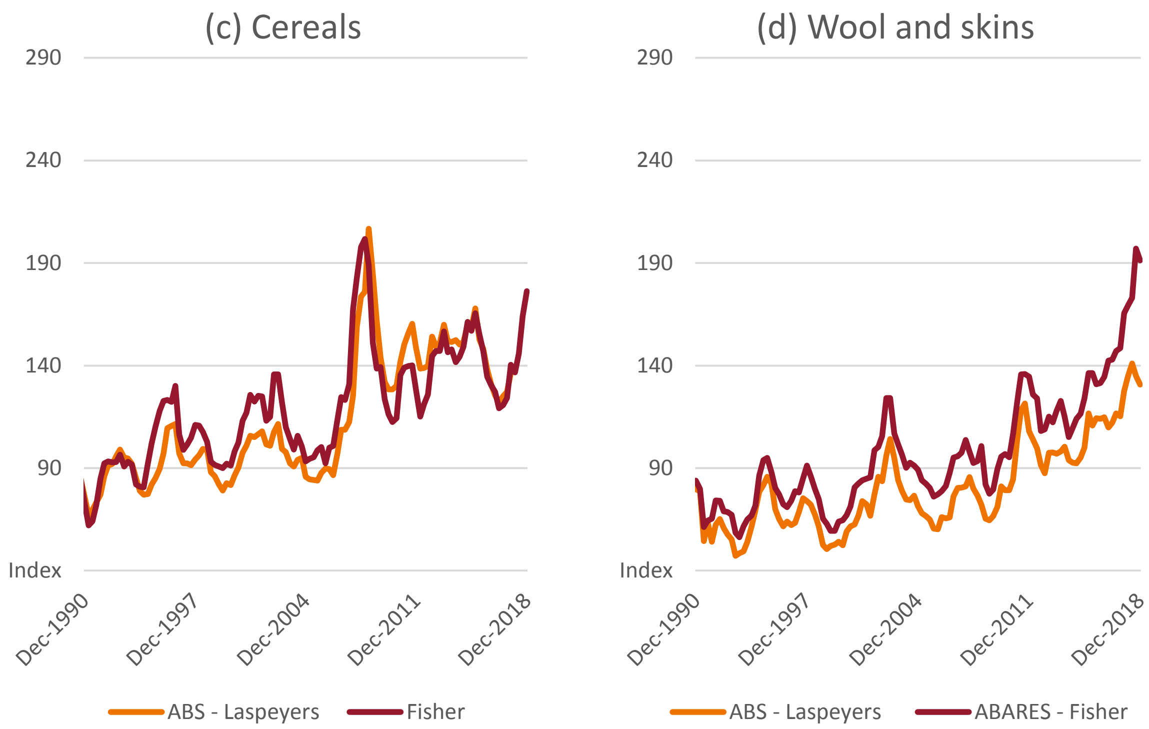
The classifications used by the ABS that most closely align to ABARES' commodity classification are the Standard International Trade Classifications. However, these classifications differ substantially in commodity composition. Only four of the indexes produced by the ABS (each panel in Figure 17) can be approximately compared with ABARES' new indexes.

The ABS also employs a hybrid approach to source data, by using both unit values and survey prices from establishments for compiling their indexes. ABARES uses unit values exclusively. The ABS also undertakes index compilation at a lower level than ABARES. Lastly, the methodologies for index compilation also differ. The ABS uses the Laspeyres index formula, however, the Fisher index formula is preferred by ABARES.

The total ABARES Fisher index is understandably lower than the total ABS index in Figure 17 panel (a) and (b). In Panels (c) and (d), the ABS indexes are either close to or lower than the ABARES Fisher index. It is difficult to pinpoint the reasons for this. It is likely due to a combination of the differences in index compilation.

Figure 17 ABS and ABARES agricultural export price indexes



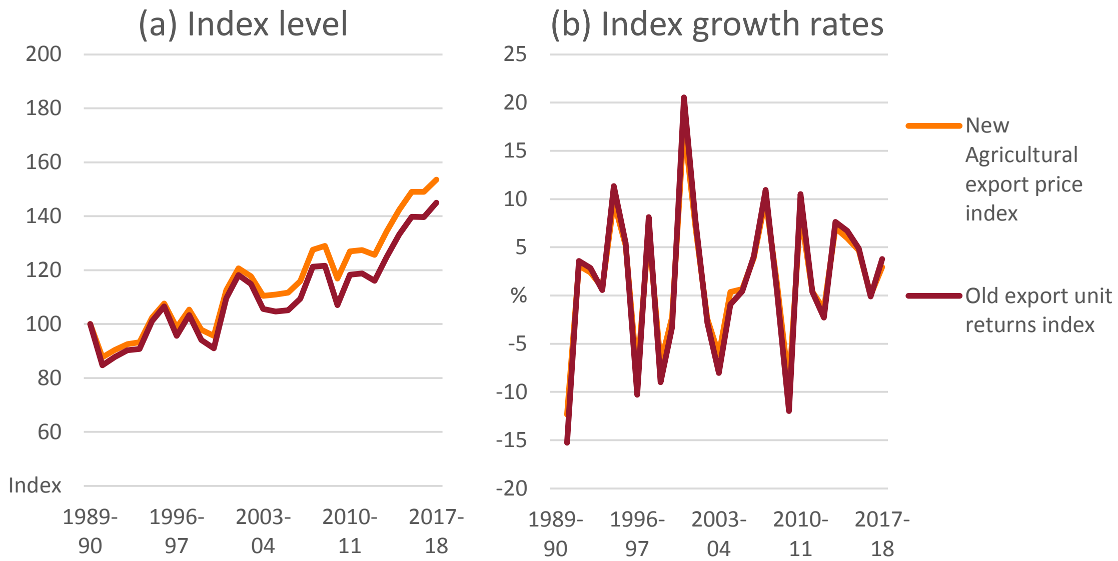


Note: The quarterly Fisher and Laspeyres export price indexes are referenced to 1989–90 = 100.
Source: ABARES; Australian Bureau of Statistics

Annual indicators

ABARES' current annual export unit returns index, outlined in Chapter 2, will be replaced as part of this project. Figure 18 compares the ABARES export unit returns index to the new version. The ABARES export unit returns index is being replaced because it was not integrated in a larger system. In other words, it did not cover all commodities, no subindexes were available and there were no corresponding volume indicators.

Figure 18 Comparison of ABARES' old and new price indexes

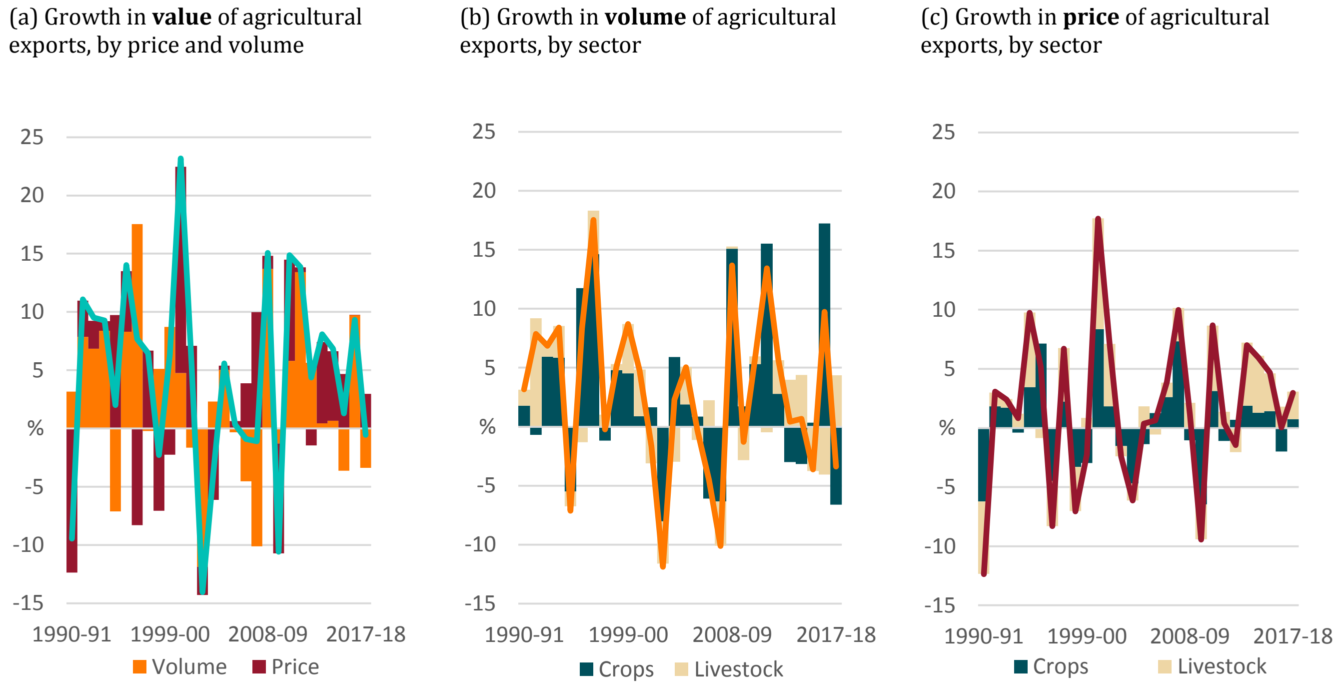


Note: Chained Fisher volume and price indexes, Reference year 1989–90 = 100.
Source: ABARES; Australian Bureau of Statistics

The commodity coverage was expanded from 30 commodities to 41 commodities, so that the commodity coverage is in line with ABARES reporting. However, it should be noted that, this increased coverage includes commodity groups where prices were not readily available. The consumer price index has been adopted for some commodities where unit values cannot be calculated because of their heterogeneous nature. This is particularly an issue with miscellaneous crops and other livestock and livestock products, which together represented about 15 per cent of the total value of agricultural exports in 2017–18. Future work will be conducted to compile appropriate price indexes for these commodity groups.

Figure 19 demonstrates the level of detail that can be obtained from an agricultural commodity export account compiled according to ABARES classifications. Panel (a) shows that the export account allows for a decomposition of growth in the value of agricultural exports into its annual price and volume components. It shows that increases in volumes exported drove growth in the value of agricultural exports from 2008–09 to 2012–13, while prices were the main contributor to growth in the following three years. An increase in the volume exported was the main contributor to growth in 2016–17. Panels (b) and (c) demonstrate that each component (volume and price) can also be studied more closely to determine what is driving growth in each. For example, panel (b) shows the growth in the volume of agricultural exports is significantly influenced by the cropping sector. It also shows that the volatility in agricultural export volumes is due to crops, while volumes of livestock exports follows a more cyclical pattern. Panel (c) shows that the livestock sector has been the main contributor to price growth in recent years. Similar decomposition of growth can also be achieved with the quarterly and monthly indexes.

Figure 19 Agricultural export performance over time



Note: Chained Fisher volume and price indexes
Source: ABARES; Australian Bureau of Statistics

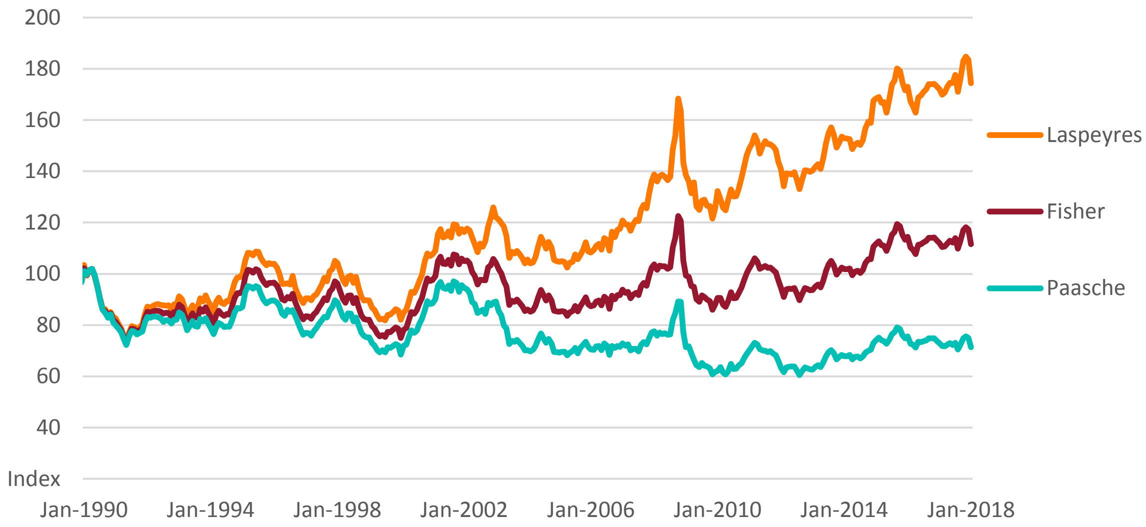
8 Technical results and issues

This chapter outlines the technical challenges associated with the composition of indexes of agricultural export prices at a monthly frequency. Generally, these issues are less significant when constructing the quarterly and annual indexes, given the comparative volatility of the underlying monthly data.

Positioning of the Laspeyres and Paasche indexes

Figure 20 shows that the monthly chained Laspeyres agricultural export price index runs well above the monthly chained Paasche index. This suggests that adopting the Laspeyres export price index would result in an upwardly biased measure for the true agricultural export price, and thus supporting the use of a symmetric index, such as the Fisher index.

Figure 20 Chained Laspeyres, Paasche and Fisher indexes



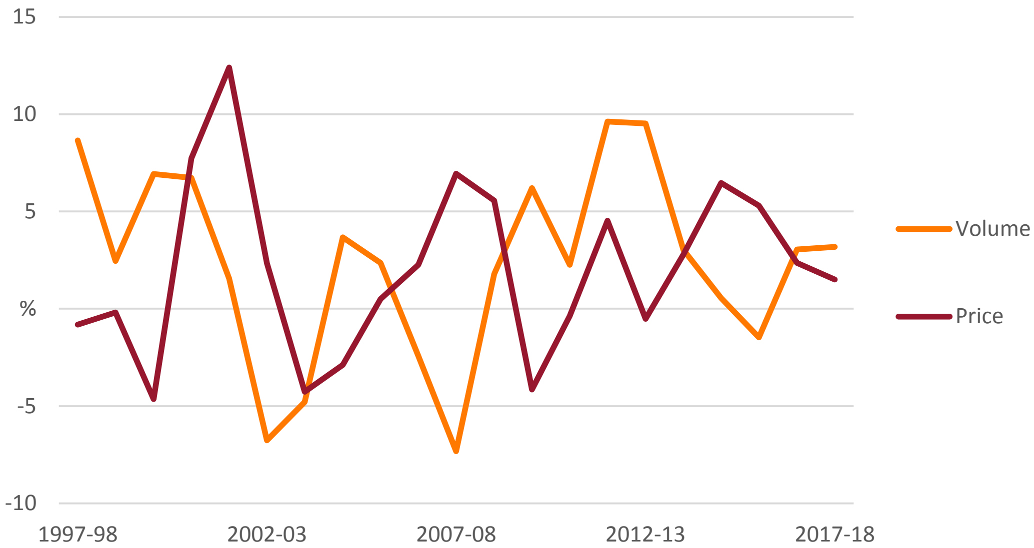
Note: Monthly Fisher export price index, reference year 1989–90 = 100.
Source: ABARES; Australian Bureau of Statistics

The finding that the Laspeyres index runs above the Paasche index suggests that the dominant relationship between the volume and price of agricultural goods exported is negative. This is the typical result for consumer price indexes where the inverse relationship between quantity and price is governed by a standard utility maximisation function. It was initially anticipated that prices and quantities in the agricultural sector would be positively correlated, characterised by a profit maximisation function. If this were the case, the Laspeyres index would be running below the Paasche index and therefore underestimating the agricultural export prices.

However, the negative relationship between export volumes and prices can be explained by the fact that agricultural production, and hence exports, is determined by producer decisions that are made well in advance of current market conditions. It is likely in many instances that key production and export decisions are made based on expected prices which are formed with reference to the commodity prices in the previous year, or longer term trends.

Moreover, production is highly susceptible to seasonal conditions, meaning that the potential for a positive relationship between price and volume could be further eroded. Figure 21 shows that at the aggregate level agricultural export volumes and prices are weakly negatively related, with a correlation coefficient of –0.23. The relationship between price and volume was particularly divergent from 2001–02 to 2008–09. This was despite there being relatively buoyant market conditions for many agricultural products, especially grains, oilseeds and dairy products. The weak growth in exports despite strong price growth over the period was likely due to non-price factors, primarily the long hot dry spell and the associated effects on yields and production. The poor seasonal conditions also reduced exports by increasing domestic consumption of feed grains.

Figure 21 Relationship between growth in agricultural export volumes and price



Note: Growth in the volume and price series' are derived from chained Fisher volume and price indexes
Source: ABARES; Australian Bureau of Statistics

Divergence of the Laspeyres and Paasche indexes

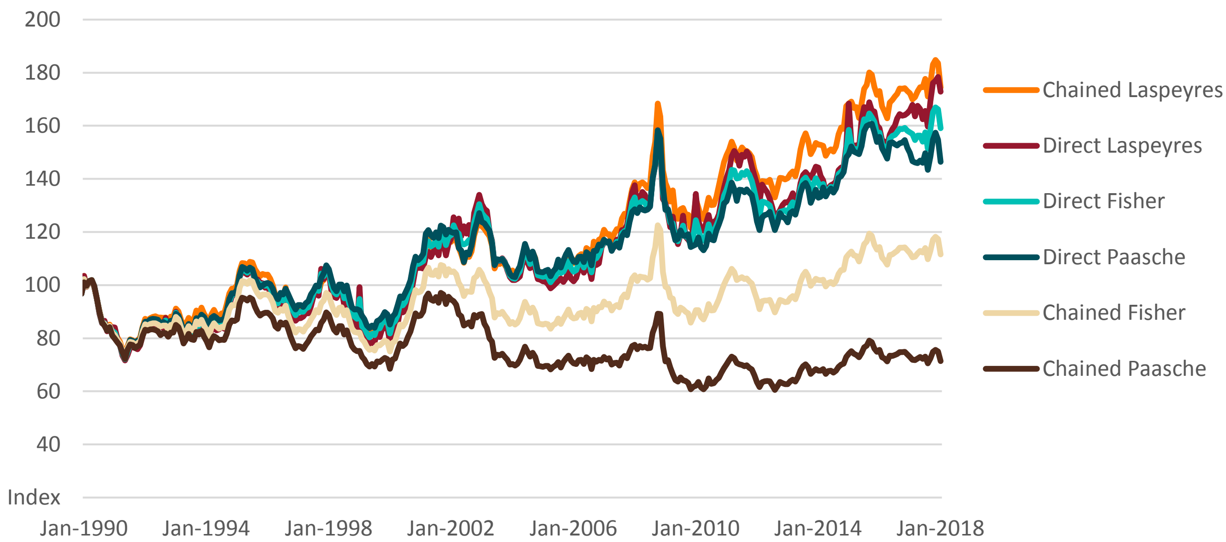
As discussed in Chapter 5, the different weights that underlie the Laspeyres and Paasche indexes are likely to result in a divergence between the two indexes over time. This is usually referred to as the Laspeyres-Paasche spread. While the spread can be explained by economic reasoning, it is nevertheless desirable that the divergence be controlled. This is because an ever-increasing gap between the Laspeyres and Paasche indexes increases the number of theoretically possible true price indexes. The Fisher index is merely one candidate of the true price index.

Chaining of an index is usually applied to minimise the Laspeyres-Paasche spread. Chaining reduces the spread because the underlying base weights of the Laspeyres index are updated more frequently, thus more closely reflecting the Paasche weights. However, the use of chaining to reduce the spread will only be possible if the data used to construct an index is not too volatile. Chaining-induced drift was found to be seriously problematic when index formulae were applied to volatile data (Frisch 1936; Hill 1988; 1993; Szulc 1987; Ivancic et al. 2011). Some of the problems are also manifest in this study. For example, when we applied Laspeyres, Paasche and Fisher indexes to the data over the period between January 1990 and January 2018 (Figure 22), we found that:

- The Laspeyres-Paasche spread increased considerably as a result of chaining.

  - The chained Laspeyres index overestimated price growth in the end of the period (using the direct Fisher index as a benchmark). However, overestimation was not observed in every month. In fact, the Laspeyres index tracked the Fisher index closely until around 2010 and most of the time after.
  - The chained Paasche index almost certainly underestimated price growth (also compared with the direct Fisher index) and the underestimation was significant and consistent over the entire period.
- The gap between direct and chained Fisher is large, leaving a high degree of uncertainty as to what the "true" long term trend of price movements should look like. This is because both direct and chained Fisher indexes are an imperfect representation of the long term price movements, with the former using out-of-date price data in the comparison and the latter suffering chaining drift.

Figure 22 Direct and chained monthly agricultural export price indexes



Note: All indexes have a reference year 1989-90 = 100. The direct indexes have a base year of 1989–90. The indexes are annually chained and re-weighted using 12-month average weights.
Source: ABARES; Australian Bureau of Statistics

Controlling drift in the chained index

This section explores a number of technical considerations relevant to reducing index chain drift.

Periodicity of chaining

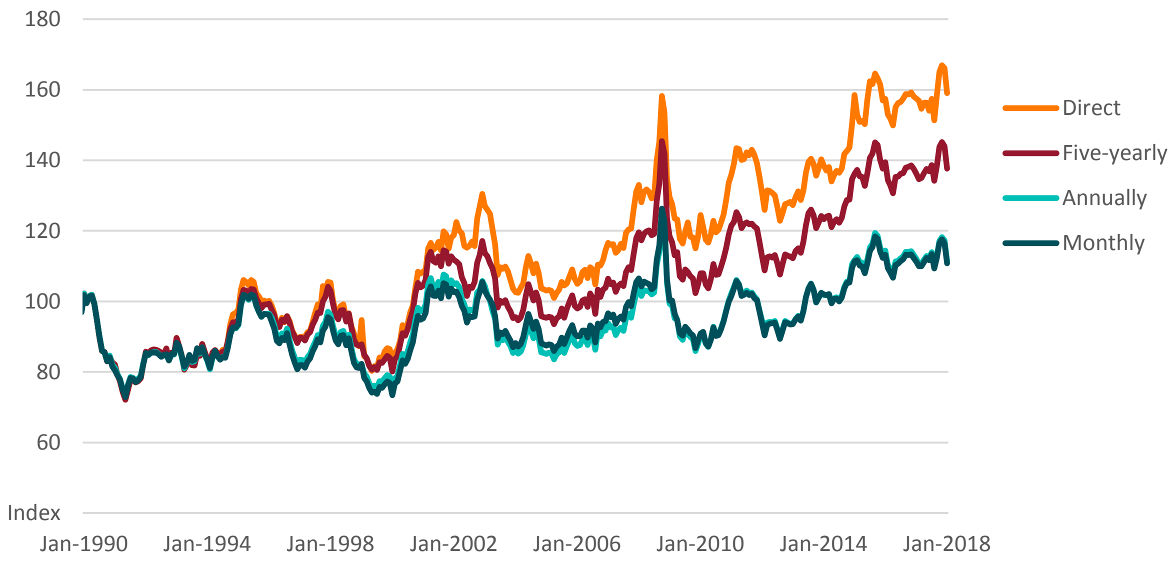
To completely remove or reduce index drift, a direct Fisher price index needs to be adopted. However, this is not desirable because a direct price index does not reflect the current composition of trade. Appendix E demonstrates the importance of using current index weights by revealing the extent of compositional change in Australian agricultural exports over time.

One way to account for index drift is to adjust the periodicity of chaining. If frequent chaining causes index drift, it may suffice to reduce the frequency of chaining to a degree that is still considered acceptable to users. Figure 23 depicts four monthly Fisher price indexes, where the only difference is the periodicity in which the index is chained (the direct index is also included for comparison). The figure shows that the more frequently that an index is chained, the lower its index value. However, there is little difference between annual and monthly chaining.

A solution to minimise this problem could be to adopt a monthly index that is chained less frequently, such as a five-yearly chained index. However, this would reduce the economic relevance of the index, particularly in an export environment where the composition of commodities exported can change rapidly (as demonstrated in Appendix E). It is also observed that annually and monthly chained indexes track each other closely, suggesting that volatilities between months (which is the main source of periodical variations in the prices of agricultural commodities) did not cause significant drift.

Our view on the impact of drift is based on the fact that most of the volatility in agricultural export prices is caused by within year fluctuations in price. This provides evidence to support our conclusion that the annually chained Fisher index is the best candidate for the monthly price index.

Figure 23 Monthly agricultural export price indexes by periodicity of chaining



Note: Chained Fisher price index, reference year 1989–90 = 100.
Source: ABARES; Australian Bureau of Statistics

Choosing the chain base

Once the periodicity of chaining is chosen (in this case we have chosen annual chaining), the chain base needs to be chosen. The chain base is the month that is used to link one year to another. June is used as the chain base for compiling the export price indexes. June was chosen because analysis is often done in financial years. Moreover, it conforms with other macroeconomic statistics produced by the ABS.

However, it should be noted that the choice of the chain base for the aggregate index can have implications for the index over time. Figure 24 shows there is a clear pattern or 'seasonality' in the aggregate price index, with relatively strong growth in average prices through September to November, and relatively lower growth in the first half of the year.

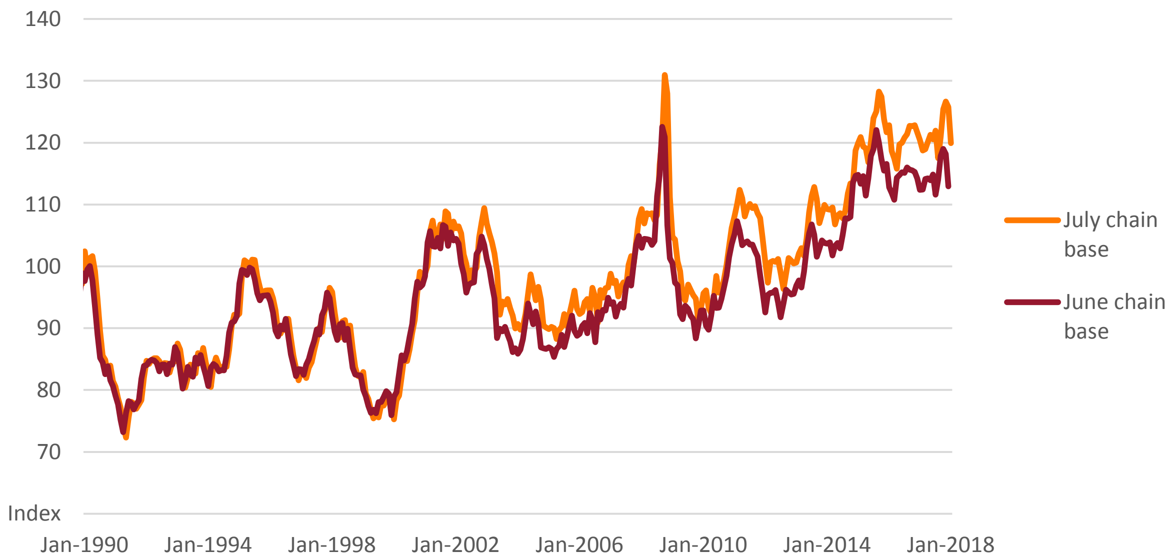
One way to account for this pattern is to conduct the annual chaining during the month that exhibits minimal price change. The average price growth of Australian agricultural export goods is low in January, March, May and July. Therefore the chain base could be set to one of these months to minimise distortion.

Figure 24 Average monthly change in agricultural goods exports, by month

Note: Monthly growth rates are averaged over 20 years
Source: ABARES, Australian Bureau of Statistics

As a demonstration, the higher average growth in June leads to a downward shift in the index. This is because the average price growth in the months following June are much lower. The choice of using June as the chain base for the index removes approximately 7 percentage points from the index over 30 years to 2017 (Figure 25).

Figure 25 Monthly export price index, July vs June chain base



Note: Monthly Fisher price index, reference year 1989-90 = 100.
Source: ABARES, Australian Bureau of Statistics

Weight construction

The inherent seasonality of agricultural commodities means that the value share of agricultural commodities (which are used as weights) are generally volatile from month to month. This can exacerbate index drift. Weights have been smoothed over a period of time in an attempt to reduce volatility in the index and to minimise index drift.

A counter argument for the use of smoothed weights is that they obscure month-to-month changes, which could lead to misleading signals. This is because monthly price changes for products out of season can be greatly magnified by the use of annual weights (Noon & Park 2009). This argument cannot be supported in this study because the purpose of the monthly agricultural export price index is to observe changes in the average level of prices over a longer period of time.

Typically, agricultural export quantities align with agricultural production in a predictable and consistent way. For example, there are predictable increases in export quantities of crops following the harvest of those crops. There are sharp increases followed by sharp falls in the value shares of these commodities as growing seasons come to an end, and producers bring their products to market.

Given the predictability of this volatility, and its occurrence over an annual cycle, weights have been constructed using a 12 month average of the value shares of each commodity, rather than simply taking each month's commodity value shares to be the weights. Constructing weights in this way eliminates the export quantity volatility inherent in a number of agricultural commodities included in the index. Therefore, smoothing weights helps reduce index drift, while at the same time maintaining reasonably timely and relevant weights.

The RBA and the ABS export price indexes use 2-year average weights. It was found that applying 2-year average weights to the monthly agricultural export price index did not lead to a substantial difference in the index. The index with 2-year average weights is slightly higher in 2017 compared to the index that uses annual average weights.

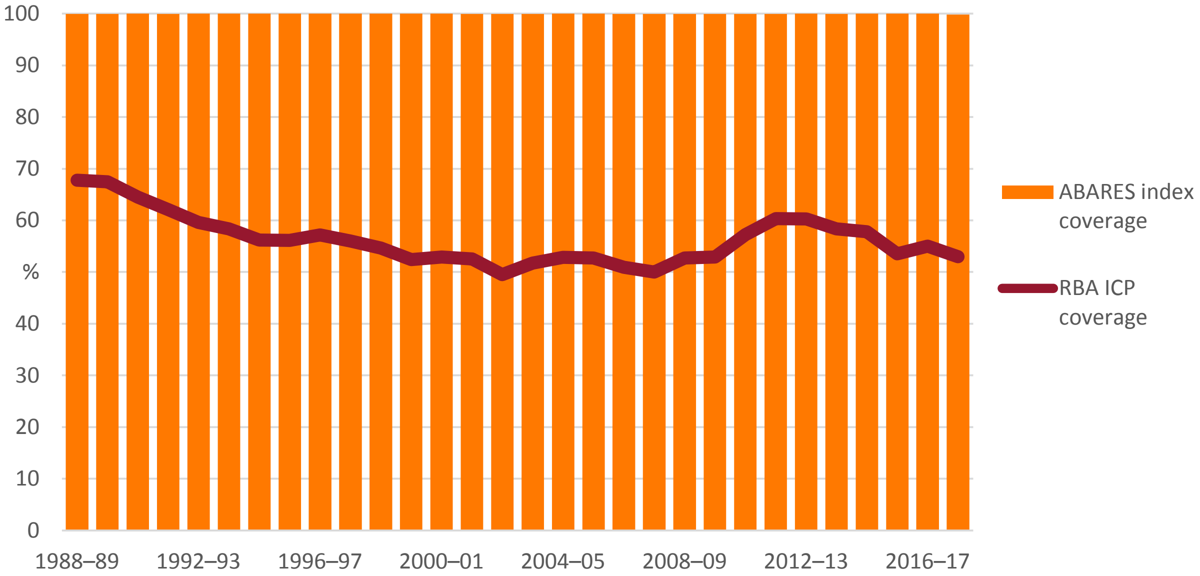
Coverage of the price index

The monthly export price index monitors the price movement of nearly all Australian agricultural export commodities. For the remaining 15 per cent, which covers miscellaneous crops and other livestock and livestock products, the consumer price index is utilised to fill in the gaps for deriving chain volumes.

The RBA rural goods index includes only the top eight traded commodities in value terms, and has a 56 per cent coverage of the total value of exports (Figure 26). The most comprehensive index that could be constructed using indicator prices is one with 12 commodities, this was via the inclusion of dairy prices to the RBA's existing eight commodities.

Utilising unit values allows for greater coverage relative to other price measures, such as world indicator prices, which are only available for highly traded commodities. It was noted that an index with larger commodity coverage is beneficial because it means that it is more representative of the agricultural sector. There is also less chance for commodities with large shares to distort the price index when those commodities experience significant price change.

Figure 26 Index commodity coverage



Source: ABARES; Australian Bureau of Statistics, Reserve Bank of Australia

Appendix A: World indicator prices

Cotlook A Index

The Cotlook A index is based on daily surveys of cotton merchants. It describes an average of export prices offered by international cotton merchants for shipment to spinning mills in the Far East, where the majority of the world's cotton is spun into yarn. Only the average prices of the five least expensive, eligible varieties of medium grade cotton fibre are used to derive the A Index.

The rationale behind the use of the cheapest values in the average is that the cheaper options could be expected to be more heavily traded. Therefore, an average price of the cheaper varieties' prices could be more reflective of transactions in the global market.

Eastern States Trade Lamb Indicator

The Eastern States Trade Lamb Indicator (ESTLI) is a livestock indicator measured by Meat and Livestock Australia's National Livestock Reporting Service (NLRS). Prices of lambs are recorded at saleyard auctions on a daily basis on the east coast. The prices are collected over seven days and compiled into a weighted average price index. The ESTLI is a broad indicator as it records prices for lambs with a carcase weight of 18 to 22kg (1st or 2nd cross, fat score 2-4). In the Australian system, producers typically get paid a carcase weight price when selling to an abattoir.

AWEX Eastern Market Indicator

AWEX records auction prices for a basket of 128 wool types (by micron, staple length and fleece weight) on a daily basis from selling centres in the eastern states of Australia. These prices are compiled into an index called the Eastern market indicator (EMI) and are weighted by production. Bidders are mainly downstream manufacturers of yarn and fabric. The EMI is considered the benchmark wool price.

The majority of shorn wool is offered by woolgrowers through the Australian Wool exchange (AWEX). It is estimated approximately 85% of wool produced in Australian is offered for sale through open cry auctions. Wool auctions are administered by the National Auction Selling Committee (NASC) and are typically rostered on 46 weeks of the year. Auctions are conducted in three selling centres: Sydney (Yennora), Melbourne (Brooklyn), and Fremantle (Bibra Lake).

Cow 90CL US cif price

The 90CL US cif price is the price paid by US importers for any 90 per cent Chemical Lean (90CL) beef from Australia and New Zealand. The import price includes insurance and freight costs (cif). Prices are in US cents per kilogram. Chemical lean beef is defined as the amount of lean red meat compared to the amount of fat in a sample of meat. 90 CL means that 90 per cent of the meat in a pack will be lean red meat and 10 per cent will be fat. Prices are sourced from the Steiner Consulting Group.

Chilled grass fed full set Japan cf price

Prices paid by Japanese importers of Australian chilled, grass fed, full sets, of beef are reflected in this price indicator. The import price includes freight costs (cf). Prices are in US cents per kilogram. Australian beef is often marketed as full-sets (multiple cuts bundled together in a single order) instead of individual cuts (Obara, McConnell, & Dyck, 2010). Prices are collected by Meat and Livestock Australia.

Sugar No. 11 Futures ICE

The Sugar No. 11 contract is the world benchmark contract for raw sugar trading. The contract prices the physical delivery of raw cane sugar, free-on-board the receiver's vessel to a port within the country of origin of the sugar.

US no.2 hard red winter, fob Gulf

This indicator measures the bulk export price of US no. 2 hard red winter wheat, 11.5 per cent protein at US Gulf of Mexico ports for prompt shipment. This is a hard wheat variety and accounts for around 30 to 45 per cent of US production and exports. The reference rate is measured on a free on board basis. Free on board prices exclude international insurance and transport costs.[8]

France feed barley, fob Rouen

The France feed price measures the bulk export price of barley (including handling and trading margin) from the port of Rouen in northern France. The reference rate is on a free on board basis.

Europe Rapeseed, fob Hamburg

The Europe Rapeseed price measures the bulk export price of rapeseed from the port in Hamburg, Germany. The reference rate is free on board.

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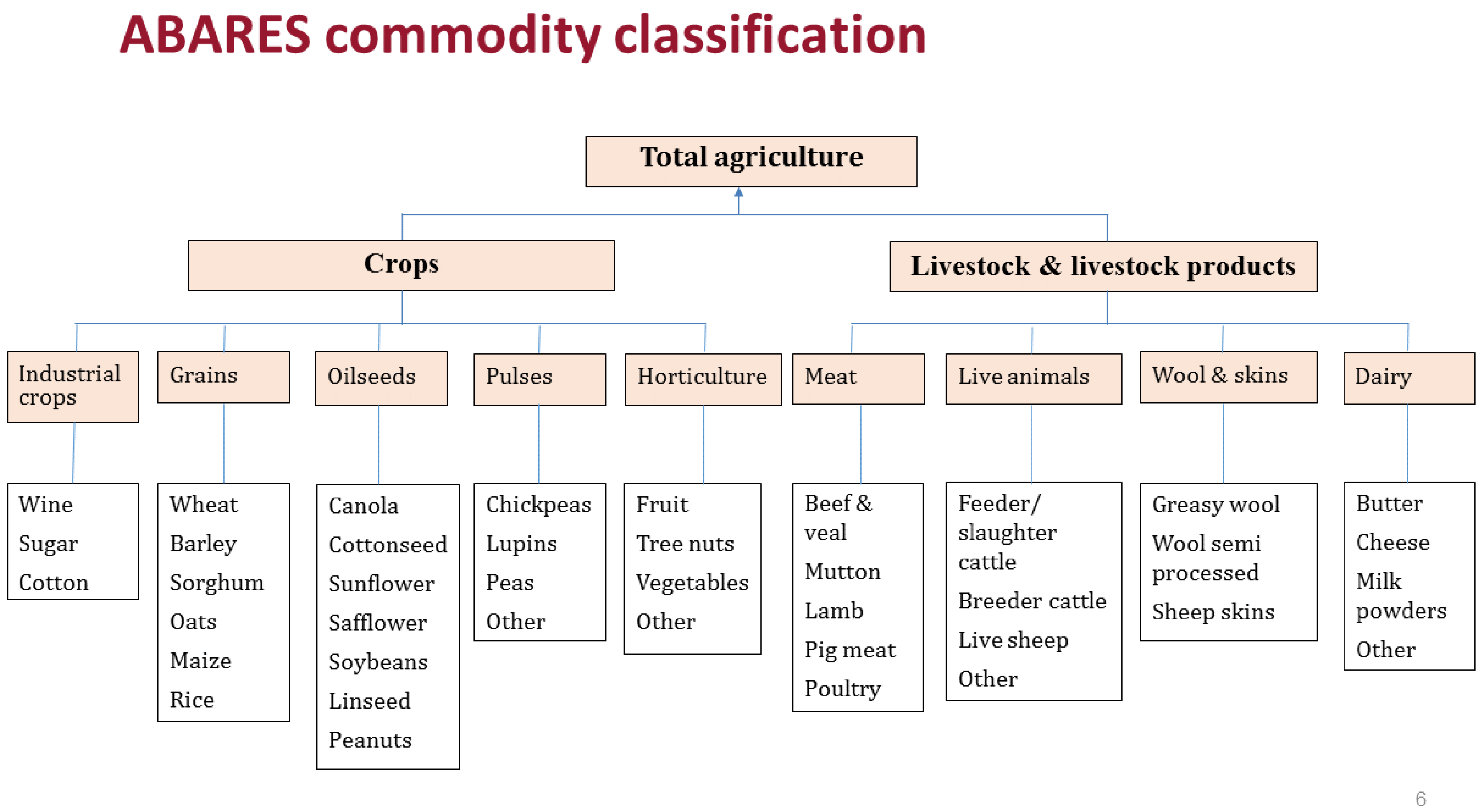
[8] The value of products measured on a free-on-board basis includes all production and other costs incurred up until the products are placed on board the international carrier for export. Free-on-board values exclude international insurance and transport costs. They include the value of the outside packaging in which the product is wrapped, but do not include the value of the international freight containers used for transporting the products (ABS 2014).

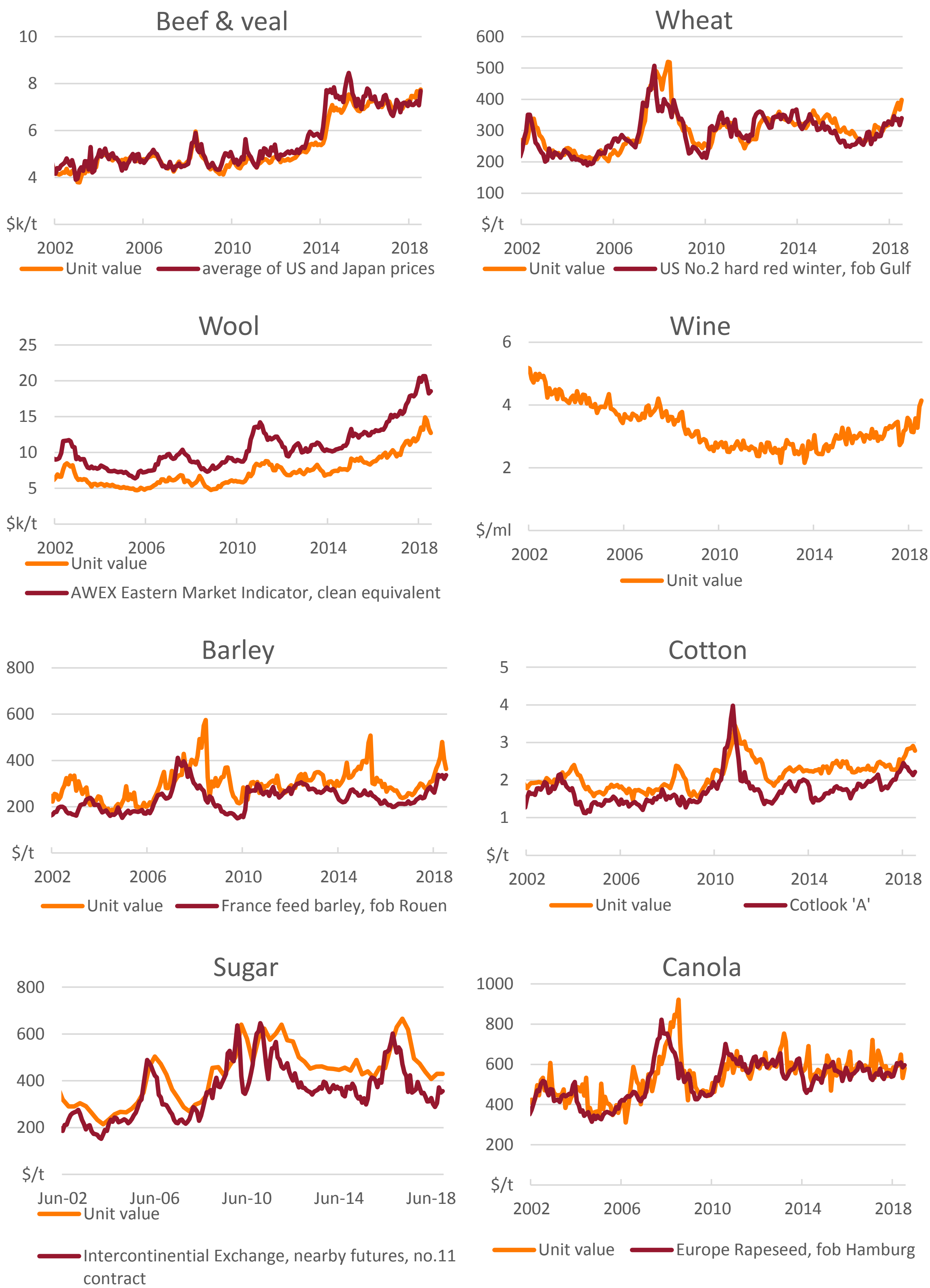
Appendix B: Structure of agricultural export account

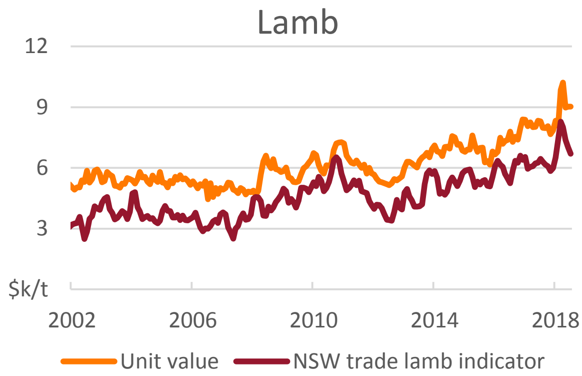


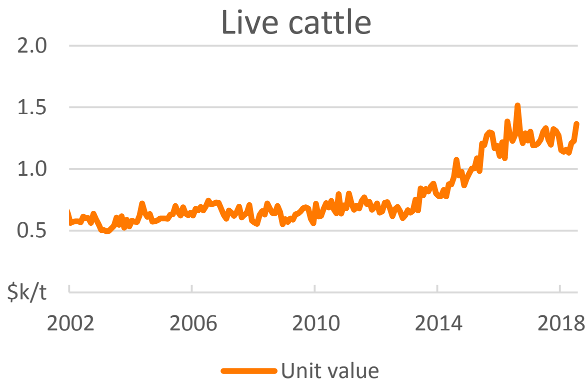
Source: ABARES

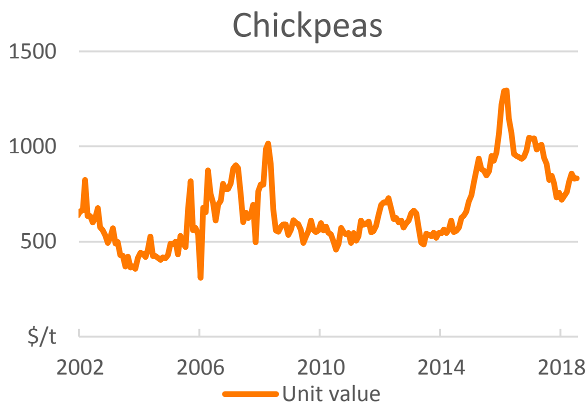
Appendix C: Commodity prices

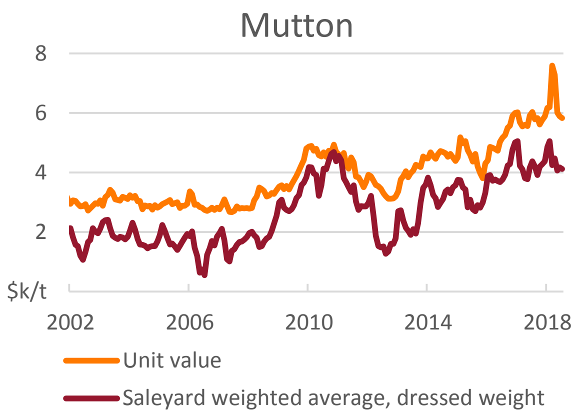
Figure C1 Australian agricultural commodity prices

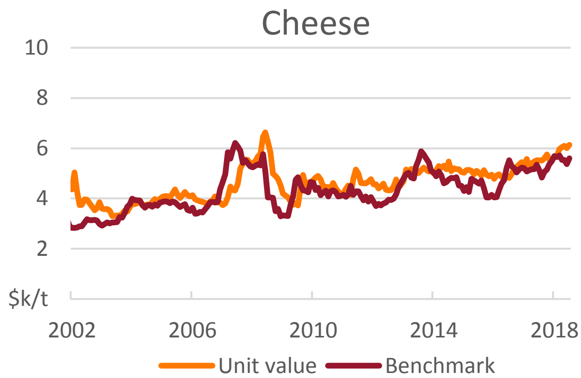


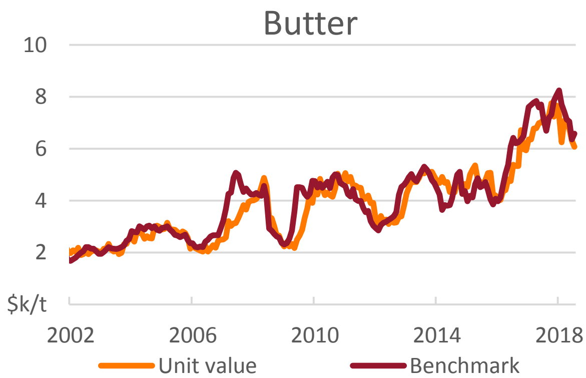


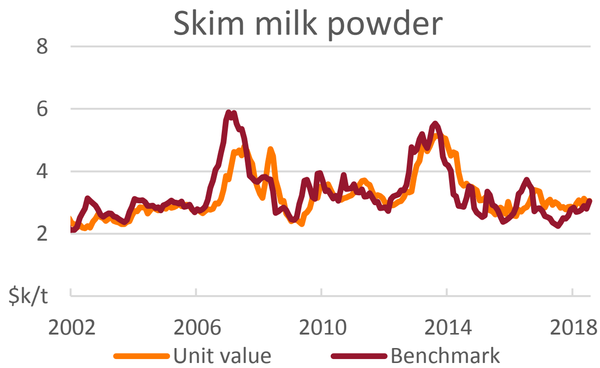












Source: ABARES; Australian Bureau of Statistics; Australian Wool Exchange; Dairy Australia; ICE Futures US; International Grains Council; Meat and Livestock Australia

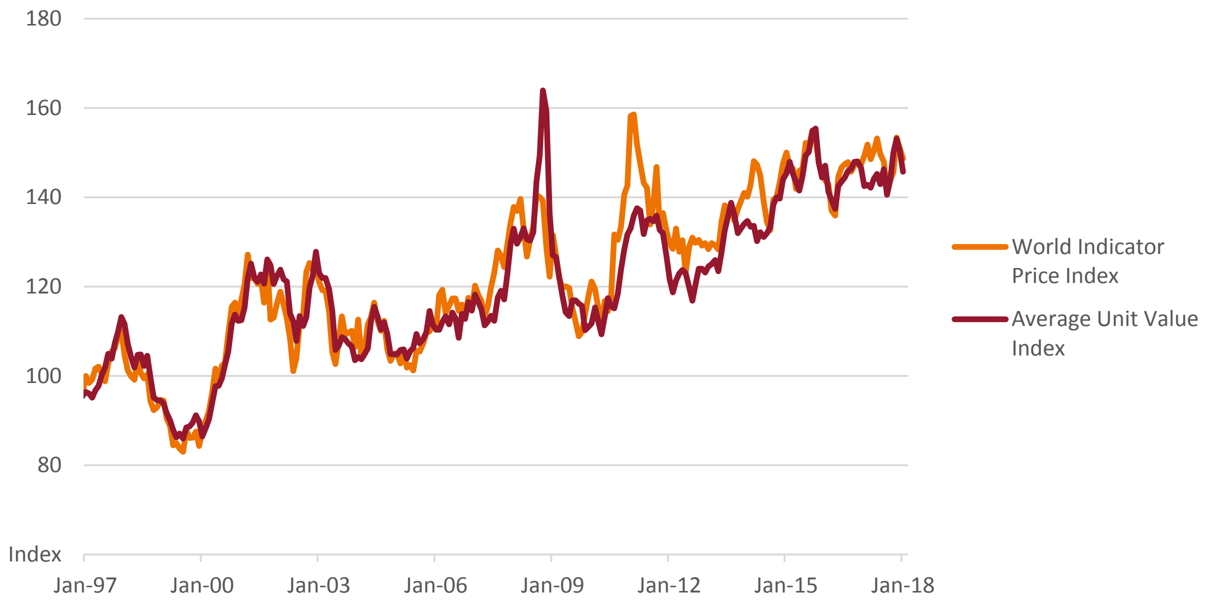
Appendix D: Comparison of indexes with differing source data

The Index of Agricultural commodity export prices is technically a unit returns index, meaning that the index price measures are unit values. Many other indexes, such as the RBA Index of Australian Commodity Export Prices, are compiled using indicator prices rather than unit values. As discussed in Chapter 4, different measures of price serve different purposes.

Figure D1 shows two price indexes, one calculated using indicator prices and the other calculated using export unit values. The indexes are broadly consistent, however there are instances when there are significant differences. This is likely to reflect a divergence in Australian agricultural export prices and the international price.

The price indexes represented in Figure D1 comprise only 12 export commodities, due to the limited number of indicator prices available.

Figure D1 Comparison of world indicator price index and average unit value index



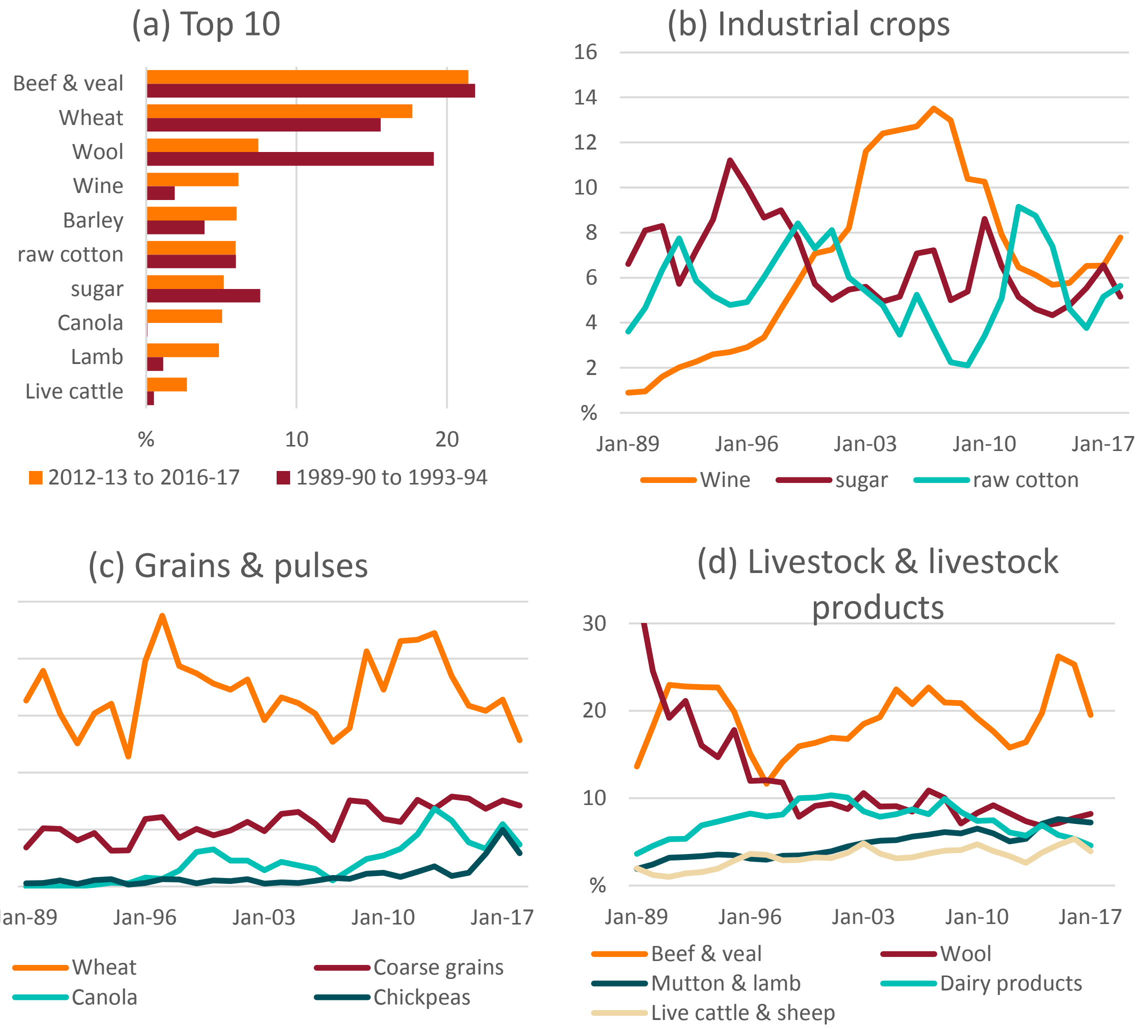
Note: Fisher price indexes, reference year 1995–96 =100.
Source: ABARES; Australian Bureau of Statistics

Appendix E: Index weights

Each export unit value in the monthly agricultural export price index is weighted according to its relative share of the total value of agricultural exports. The total is defined as the sum of the 41commodities included in the index. The weights are smoothed by averaging the expenditure shares over twelve months. This method helps reduce seasonality in the index and to reduce index drift that can occur when index weights are updated frequently in the chaining process.

Figure E1 summarises the nature of the export shares (or index weights) for select commodity and commodity groups that are in the monthly agricultural export price index. Panel (a) shows that the dominant export commodities are beef & veal and wheat. Moreover, the relative shares of these commodities to the total value exported have changed little since the early 1990s. However, Australian agricultural exports have been diversifying. Panel (a) shows that in the early 1990s the three largest commodities contributed 57 per cent of total value of agricultural goods exported. That fell by 10 per cent to 47 per cent in the period 2012–13 to 2016–17. This has been due to a significant decline in the value of wool exports. Barley, canola, lamb, and live cattle now have a more significant influence on the export price index.

Figure E1: Agricultural commodity export value shares over time



Source: ABARES; Australian Bureau of Statistics

The compositional change in the commodity mix exported can be explained by policy changes, evolving international demand and local supply constraints. These factors support the process of annual chaining and updating of the weights. If a direct index is adopted, these changes would be ignored and the price index would be of little value because it would not be representative of the sector today.

Panels (b) to (d) show the annual index weights for key commodities by industry over time. The panels reveal that there can be significant changes from year to year or every few years. Panel's (b) and (c) also show that the most important commodities (beef & veal and wheat) have volatile export shares that do not exhibit any particular trend. This volatility can provide challenges to controlling index drift. The sudden increases in export shares for chickpeas and canola in recent times could also contribute to this underlying volatility.

Appendix F: Achieving consistency in the agricultural commodity export account

Chapter 6 indicated the need to benchmark monthly and quarterly price indexes to the annual series at all levels of aggregation. This appendix provide an outline of the methodology that was adopted for benchmarking the price indexes and a brief discussion of the issues associated with the results. It makes extensive references to the work of (IMF 2017).

Benchmarking deals with the problems of combining a series of high-frequency data (such as monthly and quarterly price indexes) with a series of low-frequency data (such as annual price indexes) for the same variable into a consistent time series (IMF 2017). The two types of series may show different levels and movements and need to be made consistent over time. Because low-frequency data usually have some attractive properties (such as less subject to chaining drift)[9] and are a more reliable resource of information on long-term trends, it is a normal practice to benchmark the higher-frequency series to the low-frequency series.

Monthly, quarterly and annual price indexes are often used for different purposes. While the monthly and quarterly price indexes serve to determine the movements in their respective time intervals, the annual price index is a better indicator of the overall level and long-term trend. In this context, it is not difficult to see that the former are useful in their own right. For example, they are more informative about what precisely happens to the economy during periods of sudden and unexpected change.

The role of benchmarking is to combine all the available monthly, quarterly and annual information in the most appropriate way. In this study we consider the main objectives of benchmarking are the following:

- To calculate monthly and quarterly price indexes that are consistent with the annual price indexes over time.

[9] (IMF 2017) focuses on the benchmarking methodology and issues involved in the construction of the National accounts and is concerned with many issues that are not relevant to this study. For example, the author considered the need to retain integrity of (e.g. minimising the overall errors) the National Accounts System which contains many different types of indicators that are interconnected through an accounting framework. The other consideration is the need to minimise the predicting errors if the series needs to be extrapolated. The author suggests that, in the context of national accounting, low frequency data have other nice properties. For example, the have more comprehensive coverage, are more reliable and less likely subject to revisions than high frequency data.

- To ensure that the (annual) sum of the monthly and quarterly data is equal to the annual benchmark.
- To preserve as much as possible the monthly and quarterly movements in the respective indexes under the restrictions provided by the annual indexes.

The ideal benchmarking method should be able to meet these objectives.

In this study, we propose to use the pro rata method to distribute the temporal discrepancies—the difference between the annual sums of monthly or quarterly indexes and the annual indexes—in proportion to the values in their respective periods (i.e. 12 months for the monthly indexes and 4 quarters for the quarterly indexes). This means that it will allocate annual totals of the monthly and quarterly indexes to 12 months or 4 quarters. A pro rata distribution splits the annual total according to the proportions indicated by the monthly or quarterly observations.

Mathematically, pro rata distribution can be expressed as:

$$X_t = I_t \left[\frac{A_n}{I_n}\right] \quad \text{for } n = 1, \ldots . y, \text{ and,} \begin{cases} t = 12n - 11, \ldots, 12n & for\ monthly\ indexes \\ t = 4n - 3, \ldots, 4n & for\ quarterly\ indexes \end{cases} \quad \text{(A1)}$$

where

- X_t is the level of annual index number for the month or quarter t;
- I_t is the level of monthly or quarterly index for quarter t;
- A_n is the level of the annual index for year n;
- $\bar{I}_n$ is the annual aggregation (sum) of the monthly or quarterly values of the index for year n,
- n is the index for the years,
- y is the last available year; and
- t is the index for the month or quarter.

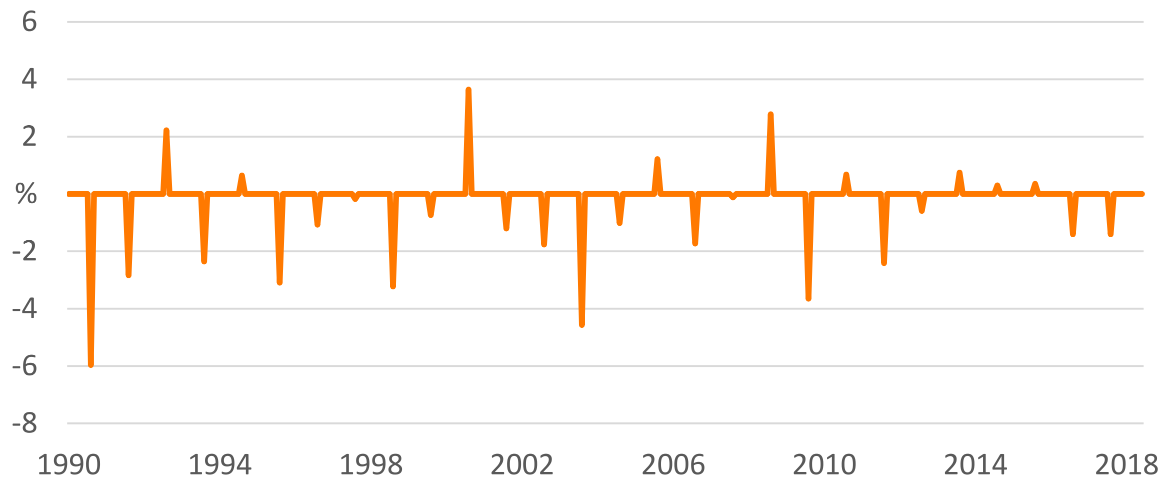
Practically, equation (A1) derives the benchmarked monthly and quarterly indexes by raising each monthly or quarterly values by the corresponding annual benchmark-to-indicator (BI) ratio defined as

$$\frac{A_n}{{I_n}_t} \quad \text{for } n = 1, \ldots . y, \qquad \text{(A2)}$$

When the BI ratio changes over time, it signals different patterns between the indicator and the annual data. A constant annual BI ratio means that the two variables present the same rates of change. As a result, movements in the annual BI ratio (equation (A2)) can help identify the quality of the monthly and quarterly indexes in tracking the movements of the annual index over the years.

The pro rata method suffers the so-called step problem. This problem arises because of discontinuities in the annual BI ratio between years (Figure F1).

Figure F1: Usage of the pro rata method between years



Source: ABARES

If the monthly or quarterly indexes show different annual growth rates than the annual benchmark, then the BI ratio will shift from one year to the next. When the annual BI ratio is used to elevate the values of monthly or quarterly price indexes for all the periods, the entire differences in the monthly or quarterly growth rates is squeezed into the first period (in the following year), while the other monthly or quarterly growth rates remain unchanged (which is a nice property from the users' perspective).

The step problem can be a significant issue for the national accounts partly because it is important to maintain the integrity of the complex system of the national accounts and, sometimes, they also need to extrapolate time series data. These issues are not a concern in this study, which led us to propose this method for the construction of the Agricultural export account.

However, it still important to highlight the consequence of benchmarking and bring it to the attention of the users of these statistics. The main consequence is that the growth rate in July (for the benchmarked monthly indexes) and September quarter (for the benchmarked quarterly indexes) differ from the original index numbers and are likely to be inaccurate, although movements in other months and quarters are perfectly consistent between the benchmarked and the original indexes. This is not perfectly desirable but we consider it as an inevitable cost of making the monthly and quarterly index a reliable long term measure of export prices.

Having said that, we are of the view that, from a users' perspective, the cost does not outweigh the practical benefit of having monthly and quarterly price indexes, because they are meant to serve purposes that differ from that of annual indexes—while the former are useful to measure short term movements and provide a timely indication of changes in export prices, the latter is a reliable long term trend of export prices. Nevertheless, readers are encouraged to be careful in interpreting the index numbers for July (in the monthly indexes) and September quarter (in the quarterly indexes) due to the step problem and use these indexes in the appropriate context. Both the original and benchmarked monthly and quarterly export price indexes are available for the benefit of users.

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