Assessing the competitiveness of Australian agriculture

By Mick Keogh, Adam Tomlinson and Mark Henry
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Foreword

While globally, agriculture is still the sector facing the most substantial trade restrictions, there has been very significant freeing up of agricultural trade over the past decade, as is clearly evidenced by the dramatic growth in the volume and value of internationally traded agricultural products over that period. Consequently, national agricultural sectors are being exposed to more competition.

The Australian agriculture sector is experiencing this change, evidenced by the continuing strong growth that is occurring in the annual value of agricultural imports to Australia, and in the emergence of new international competitors in what have been traditional export markets for Australian products.

In seeking to respond to this increased competition, it is important for policy makers and participants in the Australian agriculture sector to gain a better understanding of the factors that contribute to national agricultural competitiveness, and any mechanisms that may be available to enhance it.

The research reported here has involved an investigation of the current understanding both in Australia and internationally of the factors that contribute to the competitiveness of a national agriculture sector. Specifically, the research has involved an investigation of the potential of the development of a competitiveness indicator or index as a tool to inform decision-making about ways to enhance agricultural competitiveness.

The research found that interest in the development of indicators of competitiveness has been growing internationally, especially as a means of comparing the relative competitiveness of different nations. However, the research also found that correlations between indicators of competitiveness and national economic performance are not strong.

There has only been some preliminary research into the potential value of the development of national agricultural competitiveness indicators. Available internationally-comparable statistics were used in order to construct a trial composite agricultural competitiveness indicator for seven nations, and the resulting indicator was compared with the actual performance of the relevant agriculture sector. The result was that the constructed competitiveness indicator did not robustly correlate with national agriculture sector performance. Subsequent research involved the development of a ‘dashboard’ set of indicators of national agricultural competitiveness. A trial of the dashboard in comparing the agricultural competitiveness of Australia and the USA highlighted that it provided a more useful approach, but only to the extent of providing a starting point for further analysis.

One major limitation to better understanding relative national agricultural competitiveness was found to be a lack of robust, internationally-comparable agriculture sector statistical data, evidenced by some major flaws identified in international data used in this research. The report recommends that efforts be made to improve the quality and consistency of available agriculture sector data, at both a national and international level.

Funding for this project was provided by the Rural Industries Research and Development Corporation.
This report is an addition to RIRDC’s diverse range of over 2000 research publications and it forms part of our National Rural Issues R&D program, which aims to inform and improve policy debate by government and industry on national and global issues relevant to agricultural and rural policy in Australia by targeting current and emerging rural issues, and produce quality work that will inform policy in the long term. Most of RIRDC’s publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation
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Executive Summary

What the report is about

This report details research which investigated the potential development of a national agricultural competitiveness index as a means of enhancing agriculture sector and policymaker understanding of the factors that contribute to the competitiveness of the Australian agriculture sector, and policy or other changes that may have the potential to enhance competitiveness.

Who is the report targeted at?

The report is targeted at policymakers, academics and industry leaders who have responsibility for making decisions at a national level that may impact on, or respond to changes in, the competitiveness of the Australian agricultural sector.

Background

The reduction in international agricultural trade barriers over recent decades has increased the amount of competition in international and domestic agricultural markets. This has exposed national agricultural sectors to greater international competition, and increased the need to better understand the factors that contribute to national agricultural competitiveness.

The increased competition faced by national agricultural sectors also applies more generally to national economies, as capital and technology is able to more freely move across national boundaries. The need to better understand factors that contribute to national competitiveness has led a number of international agencies and organisations such as the World Bank, the OECD and the World Economic Forum to conduct research or developed indexes of national competitiveness, which broadly aim to assist policymakers to better understand the factors that contribute to national competitiveness.

There has been some preliminary research into the development of a similar index as an indicator of national agricultural competitiveness. The research detailed here has involved a more detailed investigation of both the value of national competitiveness indexes, and also the potential to develop such an index for use in comparing the agricultural competitiveness of Australia and other comparable nations.

Aims/objectives

The specific objectives of the research were as follows;

1. Evaluate the factors that impact on a country’s agricultural competitiveness.
2. Articulate and justify a comprehensive definition of ‘competitiveness’ (including identification of the factors impacting it) in relation to agricultural products.
3. Identify appropriate data sources to allow the analysis of each of the factors impacting on competitiveness.
4. Nominate a methodology for the development of an international agricultural competitiveness assessment that will deliver robust outcomes and ensure appropriate stakeholder engagement and ‘buy in’.
5. Propose individuals, groups and organisations to be involved with the delivery of the competitiveness assessment, either as investigators, contributors, reviewers or stakeholders.
Methods used

The research initially involved desk-top analysis of available literature on competitiveness, and available background information detailing several internationally published competitiveness indexes. Subsequent research involved the design of a trial national competitiveness index, and the collection and collation of relevant agricultural statistics associated with the factors identified for inclusion in the index.

Analysis was then carried out to ascertain the extent to which the trial national agricultural competitiveness index accurately reflected national agriculture sector performance for seven different nations. The research then involved further analysis to identify and quantify a small number of high level agricultural sector indicators that may be of use as part of a ‘dashboard’ to be used to better understand national agricultural competitiveness.

Results/key findings

The research identified that there is a body of published literature analysing factors that contribute to national competitiveness. However, despite substantial international efforts directed at the development and reporting of national competitiveness indicators, there does not appear to be a strong correlation between those international competitiveness indicators and national economic performance.

There has not been a similar level of analysis directed at understanding national agricultural competitiveness, although some work has been carried out by the OECD.

Informed by the available literature, a list of factors was developed that were considered likely to be important in affecting national agricultural competitiveness. Of these, half were national economic factors, and half were agriculture-specific factors. Relevant time series statistics were collected for each of these for seven different nations, and these were used to calculate a trial national agricultural competitiveness index. When the results for the index were compared with national agricultural performance, the correlation between the two was found to be weak, variable, and often in the reverse direction to what would normally be anticipated.

Statistical analysis was subsequently utilised to apply different weightings to the factors included in the index. The competitiveness index calculated using this approach was again found to have significant deficiencies in terms of the correlation between the weighted index and national agriculture sector performance.

The research concluded that two deficiencies prevent the development of a national agricultural competitiveness index. The first is the quality and availability of comprehensive agriculture-sector statistics that are relevant to all the factors thought to contribute to the relative competitiveness of a national agriculture sector. The second is the complexity and variability of factors that contribute to an agriculture sector’s competitiveness, with available evidence suggesting that the importance of different factors varies from nation to nation, and over time.

Implications for relevant stakeholders:

The implications for relevant stakeholders are that the development of national agriculture competitiveness indicators as a means of enhancing policymakers and industry participants’ understanding of the relative competitiveness of a national agriculture sector is not recommended.

An alternative approach, consisting of a dashboard of different indicators, does provide a better perspective of the relative competitiveness of a national agriculture sector, but only to a limited extent, and only as a starting point for more detailed analysis.
The research has highlighted the deficiencies in both national and international agricultural statistics collections, which make relevant comparisons of national agriculture sectors quite difficult.

The report recommends that the Australian Government, relevant national and international agencies and the Australian agricultural industries take steps to improve the quality and comprehensiveness of Australian agricultural statistics.
Introduction

The Australian agriculture sector is fully exposed to international competition, both in export and in domestic markets. (OECD, 2014). In both these markets, competition is increasing. In export markets, newly emerged exporters from South America and Eastern Europe have rapidly increased their market share of global agricultural export markets over the past decade. In the Australian domestic market, there has been a 70% growth in the annual value of food and beverage imports into Australia over the past seven years. (ABARES, 2014).

This has occurred at a time when, partly as a consequence of the strong economic performance of the national economy over the past two decades, Australia has become one of the highest cost nations globally, especially in relation to business inputs such as labour.

These developments have increased the competitive pressure facing Australian farm and agricultural businesses, and highlight that it is critically important to the future of Australian agriculture that the sector maintain and improve its competitiveness, relative to the agriculture sectors of other nations.

As transport and telecommunication services become more efficient and global trade increases, this challenge is increasingly facing nations and firms more generally. The increasing competitiveness of markets has enhanced the focus of businesses and governments on policy measures that may enhance the competitiveness of firms within an economy, and has led to the compilation of internationally-recognised competitiveness indexes, that have the aim of assisting policymakers and firms to better understand how their competitiveness is changing over time.

Initially, most of the focus was on national competitiveness, but more recently researchers have begun to analyse and develop indicators of competitiveness at a sectoral level within national economies. Examples include information and computing technologies (ICT), manufacturing and education.

The increasingly global nature of agricultural markets has encouraged a greater focus on research into agricultural competitiveness, however, identifying all the factors that contribute to the relative competitiveness of a national agricultural sector is a complex task.

National agricultural sectors consist of a varied mix of firms, ranging in size from the smallest family farm to the largest multi-national agribusiness conglomerate. All these firms exist within a national policy and economic framework, and respond in different ways to the variety of policy and market signals they receive.

The market signals are many and varied, and include changes in relative input costs, labour costs and availability, technology, as well as changes in consumer incomes, tastes and even fashion. Changes in any of these can obviously affect the apparent competitiveness of agricultural firms or a national agricultural sector, irrespective of changes in policy.

Farm and agricultural firms interact with a wide range of other firms in the economy, and are affected by the policy settings relevant to the national economy. At the same time, most nations have a range of different policy settings that are specific to agriculture, and these also influence how agricultural firms operate.

The relevant factors that determine the competitiveness of firms within a sector of a national economy are very complex and this complexity makes it difficult for policymakers or sector participants to understand the impact of different policy measures on sector competitiveness, or to understand how sector competitiveness is changing over time.
The development of a competitiveness indicator for Australian agriculture has the potential to provide a tool whereby the impact of changes to either national or agricultural policy on the competitiveness of the agriculture sector can be better understood, and more importantly whereby changes in relative competitiveness can be monitored over time, as factors within and outside Australia change.

The research detailed here involved analysis associated with the potential development of a competitiveness indicator for the Australian agriculture sector. It included an examination of the concept of competitiveness, analysis of existing competitiveness indicators that are currently published by various organisations, and the development and validation of a trial competitiveness indicator for the Australian agriculture sector.
Objectives

The specific objectives of the research were as follows:

1. Evaluate the factors that impact on a country’s agricultural competitiveness.
2. Articulate and justify a comprehensive definition of ‘competitiveness’ (including identification of the factors impacting it) in relation to agricultural products.
3. Identify appropriate data sources to allow the analysis of each of the factors impacting on competitiveness.
4. Nominate a methodology for the development of an international agricultural competitiveness assessment that will deliver robust outcomes and ensure appropriate stakeholder engagement and ‘buy in’.
5. Propose individuals, groups and organisations to be involved with the delivery of the competitiveness assessment, either as investigators, contributors, reviewers or stakeholders.

Scope and Methodology

The research associated with this project involved a series of linked sub-projects, which were as follows:

Sub-project 1: Literature review on competitiveness

A review of available literature on competitiveness assessment, and relevant objective indicators was undertaken. The information gathered during this review discusses the definition, purpose, methodology, potential and validation processes for measuring competitiveness. An expert advisory committee was involved in guiding the development of the literature review.

Sub-project 2: Identification of relevant factors impacting on agricultural competitiveness

A list of factors relevant to an agricultural competitiveness assessment process was established. This list was considered in detail by the expert advisory committee, who had the role of reaching agreement on the factors that should be included in a trial quantitative assessment of the competitiveness of a national agriculture sector.

Sub-project 3: Identification of suitable factor indicators

This involves the identification of quantifiable indicators to be utilised for each of the relevant factors that were agreed to be included in the competitiveness assessment. Consideration was given to the extent to which statistics associated with the indicators identified were available for other national agriculture sectors that may subsequently be included in, or utilised in the process. The expert advisory committee assisted in finalising and prioritising the indicators that were utilised in the competitiveness assessment process.

Sub-project 4: Identification of potential international participants and commodities

This involved reaching agreement on the international competitors to be included in initial international comparisons, and also the appropriate commodities to be included in an initial competitiveness assessment. This required some analysis and consideration in selecting international competitors for inclusion, given the complexity of commodities and market segments that constitute the agricultural sector.
Sub-project 5: Agricultural competitiveness assessment trial

A trial of the proposed agricultural competitiveness assessment process was carried out, utilising information and indicators relevant to a limited number of commodities, and for a limited number of international agricultural sectors. This entailed a competitiveness assessment for seven countries including Australia and five agricultural commodities. An important aspect of this part of the research was the validation of the assessment results against national performance over time.

Sub-project 6: Development of an agricultural competitiveness assessment ‘business plan’

A potential business plan for the future development of the agricultural competitiveness assessment process was considered. The business plan aimed to expand the competitiveness assessment, and to consider ways to engage relevant stakeholders in the agricultural sector of Australia and also internationally. The business plan identified relevant stakeholders within Australia as potential contributors to future iterations of an agricultural competitiveness assessment process.

The report which follows arises from the activities associated with the above research.
Review of Literature

The Australian agriculture sector has evolved considerably over the past two hundred years. After an initial period post-European settlement during which the focus was on simply producing enough food for survival, the agriculture sector expanded and rapidly developed into a source of export revenue for the nation. Much of the expansion over the first 150 years involved the utilisation of additional land and water resources, with the agriculture sector also supported by a wide variety of different government measures all aimed at helping the development of small family farms and shielding them from competition.

By the 1990s, governments began to focus on the need to enhance productivity in the economy in order to increase national competitiveness. It was recognised that regulated markets were limiting the flexibility of farm businesses to respond to changing market conditions, and hence to become more productive. The major reforms in agricultural policy in Australia that have occurred over the past two decades, in particular the deregulation of agricultural marketing arrangements, have been heavily influenced by a desire to enhance agricultural productivity.

Productivity growth in agriculture, which reflects increases in the efficiency of production processes over time, is a key determinant of farm profitability and an important mechanism for maintaining the international competitiveness of Australian agriculture (Gray et al., 2011). However, while productivity is an important factor contributing to the competitiveness of an economic sector or a nation, it is not the only factor. Distortionary agricultural trade policies, for example, have been and continue to be a major factor impacting on Australian agriculture’s ability to compete in world and domestic markets.

Australian agriculture is highly reliant on export markets, with over 60% of domestic agricultural production exported each year. Even the domestic market (which is the largest single market served by Australian agricultural businesses) is relatively open to products imported from overseas. As a result, businesses in the Australian agricultural sector are highly vulnerable to any factors that impact negatively on competitiveness.

An improved understanding of the various factors that are important in determining the competitiveness of the Australian agricultural sector should assist sector participants and policymakers to gain improved insights into policy or other changes that may be required to enhance the competitiveness of the sector. It should also be useful in identifying those factors that provide Australian agriculture with a competitive advantage, and for guiding policy development and decisions about the application of limited resources to maximise the sector’s competitiveness.

Having said that, assessing the competitiveness of a national economic sector is a complex task, as there are a wide range of different factors (from climate to exchange rates, for example) that can impact on the apparent competitiveness of an agriculture sector at any point in time, either in isolation or in combination. Quantifying these, understanding their interactions, and assessing changes in them will require considerable resources and effort.

The literature review examines available academic research on issues such as the definition of competitiveness, the uses of competitiveness scoring systems, the methodologies utilised in measuring competitiveness, and the validation processes utilised to assess the relevance of competitiveness indicators.

Definitions of competitiveness and other related terms

This section of the literature review analyses the different definitions of the term ‘competitiveness’. This includes the definitions used by private institutions, government institutions, economists and researchers. This section also examines the definitions of some related terms.
The factors that make one enterprise or nation more ‘competitive’ than another have been the subject of academic interest for a considerable time, and this level of interest has increased as national economies have become increasingly enmeshed in the globalised business and trading environment.

A key private sector institution that has a strong focus on gaining a better understanding of factors impacting on relative competitiveness is the World Economic Forum (WEF) which was established in 1971. Initially, the WEF defined competitiveness as the ability of one company or group of companies to do as well as, or outperform, another company or group of companies while taking into account the framework conditions in the country. This definition has evolved over time, and is now “the set of institutions, policies, and factors that determine the level of productivity of a country.” (Schwab, 2014)

This definition is taken a step further by the WEF and used to describe how, in turn, the level of national productivity determines the level of prosperity that can be reached by a nation as well as the rates of return that can be obtained from investments in an economy. These two factors are considered to be fundamental drivers of a nation’s economic growth rate, which means that a more competitive economy is one that is likely to achieve higher rates of economic growth over time (Schwab, 2014).

The WEF compiles an annual publication which provides rankings of the competitiveness of nations based on the Global Competitive Index (GCI). The GCI evaluates the competitiveness of national economies using a range of factors, modified to some extent by the stage of economic development that has been reached by that nation. The three stages of development for nations included in the GCI are;

1. factor-driven (a seller of basic products),
2. efficiency-driven and
3. innovation-driven (Schwab, 2014).

The reason for differentiating between nations at different stages of economic development is that the importance of different factors changes as economic development occurs. For developing nations, labour costs are usually relatively low and labour productivity is not a major factor impacting on competitiveness, with factors such as governance and transport infrastructure likely to be key determinants of competitiveness. However, as a national economy develops and wages increase, labour costs become more significant and labour productivity must improve in order for the nation to remain competitive.

The Institute of Management Development (IMD) is another private sector institution with a strong focus on international competitiveness, particularly between nations. The IMD defines the competitiveness of nations as the ability of a nation to create and maintain an environment in which enterprises can compete. The IMD divides the national environment into four main factors, including;

1. economic performance,
2. government efficiency,
3. business efficiency and
4. infrastructure (IMD, 2014).

The Organisation for Economic Co-operation and Development (OECD) is a key public sector institution that has a strong focus on gaining a better understanding of factors impacting on relative competitiveness. The OECD has defined competitiveness as the ability of companies, industries, regions, nations, and supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis (Hatzichronoglou, 1996).

Another public sector institution that has defined competitiveness is the European Commission. The European Commission, which represents the interests of member states in the European Union (EU), has defined competitiveness as “a sustained rise in the standards of living of a nation or region and as low a level of involuntary unemployment as possible.” (Bleischwitz et al., 2007).
Economists and researchers have often referred to competitiveness as an elusive concept, much studied by business theorists and much invoked by politicians and commentators, but frequently dismissed as irrelevant or unimportant by economists. Even though applied economists have been only too aware of the importance of competitiveness as a determinant of macroeconomic performance, they have tended to focus on the narrow concept of relative cost competitiveness (Neary, 2005).

Researchers have highlighted that there is no consensus on how competitiveness should be defined, nor how to measure it precisely (Latruffe, 2014). Despite the fact that improving a nation’s competitiveness is the central purpose of every economic policy, the lack of a unanimously accepted definition represents a source of constant controversy, the main argument being that it is quite dangerous to construct an economic policy around such an amorphous and interpretable concept (Anca, 2012).

Competitiveness can also be viewed as an unfortunate term, as it suggests nations are competing like enterprises chasing market share or athletes competing for medals, and that one nation doing better economically means that others are doing worse. This is not the case, as in reality a nation such as Australia benefits when other nations become more competitive and there is stronger economic growth in the rest of the world (Hawkins, 2006). This highlights that national competitiveness should be considered to be a relative concept, rather than an absolute one.

Economists and researchers with a primary focus on the agricultural sector have also examined the definition of competitiveness.

Agricultural competitiveness can simply be defined as the ability of an agricultural firm (including a farm) to face competition and to be successful (Latruffe, 2014). Competitiveness is the ability to sell products that meet demand requirements (price, quality, quantity) and, at the same time, ensure profits over time that enable the firm to thrive. Competitiveness may be considered in the context of a domestic markets (in which case firms, or sectors, in the same country are compared with each other) or in an international context (in this case, comparisons are made between firms in different countries).

There has been research undertaken to review competitiveness from an international trade perspective, and this has involved alternative definitions. This highlights that the definition of competitiveness depends on the purpose of a study, the commodity in question and the level of analysis (Sarker, 2014).

Research undertaken by the OECD Food, Agriculture and Fisheries division arrived at a definition based on what constitutes competitiveness for an agricultural sector. A competitive environment for agricultural growth was considered to comprise an economy-wide set of non-distorting and stable policies, adequate provision of public goods, good governance through laws and regulations that are conducive to private-sector economic activity while addressing market failures, and strong and effective institutions through which government measures and actions are operationalised (Díaz-Bonilla et al., 2014).

A definition of agricultural competitiveness must, of necessity, include some consideration of the definition of agriculture. In particular, it is important to define the boundary between the farm sector and the upstream and downstream supply chains.

Agriculture is the science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, fibre, and other products (Oxford-Dictionaries, 2014). There are broader definitions of the term “agriculture” which includes activities such as forestry, hunting, and fishing, as well as cultivation of crops and livestock production (FAO, 2014). This group of activities corresponds to Divisions 1-3 of the International Standard Industrial Classification system. Generally, however, the most commonly used definition of agriculture is one that refers only to activities classified under Division 1 of the above classification system, which includes two basic activities, namely the production of crop products and production of animal products.
Agricultural activities in the crop and animal production division exclude any subsequent processing of agricultural products such as manufactured food products and beverages, which are included in divisions 10 and 11 of the International Standard Industrial Classification, respectively. The crop and animal production division also excludes field construction such as agricultural land terracing, drainage and preparing rice paddies, as well as buyers and cooperative associations engaged in the marketing of farm products (UNSD, 2014).

Another important concept to consider in relation to competitiveness is the concept of ‘comparative advantage’. Comparative advantage is widely believed by economists to be a key determinant of international production and trade patterns (Hawkins, 2006). The principle of comparative advantage holds that the world is better off if nations specialise in producing those goods and services that each is able to produce at a low opportunity cost. Opportunity cost is defined as the ‘next-highest’ valued alternative use of a particular resource. This means that even in the event that one nation can produce a range of different goods more cheaply than a trading partner, both nations will be better off if each nation specialises in producing those goods that have the lowest opportunity cost, and engaging in trade.

The conclusion is that no matter how talented a nation’s people, or how fertile the land, a single nation cannot have a comparative advantage in everything, implying that all nations have a comparative advantage in some areas of economic activity (Hawkins, 2006), and can benefit through trade.

The concept of comparative advantage is one associated with a free trade environment, and this is what distinguishes it from competitive advantage, - that is to say competitiveness (Latruffe, 2014). Competitive advantage is measured with market (existing) prices, while comparative advantage should be measured with equilibrium prices (Siggell, 2007).

In the context of this study, competitiveness can be defined as a relative measure of the combined impact of a range of factors that affect the performance of businesses within a sector producing and trading goods and services, as well as supporting employment and raising living standards, over time.

The agricultural sector can be defined as the group of industries involved in cultivating the soil for the growing of crops and the rearing of animals to provide food, fibre and other products.

The agricultural sector excludes the food, beverage and fibre manufacturing industries as well as field construction industries and merchants of farm products. This exclusion could result in a definition that could be considered too narrow in the context of the work of Porter (Porter, 1990) who has developed theories of competitiveness based on ‘clusters’ of associated businesses and industries. For agriculture, this by definition would incorporate processors downstream from the farm gate.

However, for the purposes of international comparisons, the broadening of a definition of the term agriculture to include associated processing sectors would create very significant definitional and statistical challenges, well beyond the scope of this research. It is also relevant to observe that the inclusion of downstream sectors is something which could be included in subsequent analysis, should it appear useful.

**Reasons for assessing competitiveness**

This section of the literature review provides an overview of the reasons stated in literature for assessing competitiveness. This involves reviewing the purpose of some existing competitiveness assessments compiled by both private and public sector institutions.

The competitiveness concept has generally been seen as an opportunity for stimulating meaningful discussions about decisions on economic reforms and productivity-enhancing investments, such as transport systems. However, in some circumstances, the parties engaged in these discussions have not fully understood the purpose for assessing competitiveness in the first place, and these misunderstandings have ultimately led to a poor interpretation of results.
The Global Competitiveness Index (GCI), which is compiled each year by the WEF, has been much referred to in the media, although it is not clear the extent to which it is used as a tool by policy makers. The compilers of the GCI state that they aim to remain at the forefront of the effort to provide policy makers and business and civil society leaders with relevant tools that can measure and benchmark the drivers of competitiveness and prosperity in an economy (Schwab, 2014).

The GCI is a composite index which amalgamates quantifiable changes in the key competitive factors of nations, and the mechanisms and interrelations that are considered to effect economic growth and the level of present and future prosperity of a nation. For example, the success of an economy depends on competitive factors such as available talent and a high capacity to innovate (Schwab, 2014).

Similar to the GCI, the World Competitiveness Yearbook (WCY) which is compiled by the IMD, also assesses the competitiveness of a country. The IMD developed the WCY based on the assumption that with open world markets, nations need to increasingly focus on the ability to compete. The results of the WCY illustrate how well countries manage their economic and human resources to increase their prosperity.

The IMD highlights the important role that national policies and economic settings play in assessing competitiveness by noting “over the past 30 years, the economic responsibilities of government have – for better or worse – increased to such an extent that it is simply impossible to ignore their influence on modern economics.” (IMD, 2014).

As is the case for the GCI, it is not clear the extent to which the WCY is used by policymakers to guide decision-making, although its use by business advocacy organisations can be argued to indirectly impact on policy decisions.

The European Commission has stated that it developed the Regional Competitiveness Index (RCI) to improve understanding of competitiveness at the regional level, and so that the strengths and weaknesses of member states in the EU could be evaluated. The development of the RCI commenced in 2008 by building on the existing GCI methodology. More broadly, the RCI was also established by the European Commission so that it could play a critical role in the debate on the future of cohesion policy (Annoni and Dijkstra, 2013).

The European Commission has also assessed the competitiveness of the food industry in the EU region. The objective of the food industry assessment was to determine;

- the actual competitiveness of the EU food industry compared to other leading countries,
- the impact of the European food legislation on the industry’s competitiveness, and
- the impact of economic and institutional constraints, as well as agricultural trade policies on the competitiveness based on model simulations (Wijnands et al., 2007).

Competitiveness assessments have been used as a means of encouraging action to be taken to maximise future opportunities. For example, a recent research report published by McKinsey Australia (Lydon et al. 2014) assessed the competitiveness of different economic sectors in Australia, utilising what was termed a Relative Competitiveness Score. This score was calculated as the ratio of Relative Labour Productivity and relative Input Cost Efficiency.

Using this measure, the research concluded that Australia is most strongly competitive in agriculture, and in some extractive industries associated with mining.

The main focus of the research and the use of the competitiveness measure was to encourage policymakers to devote greater resources and policy attention to those activities in which Australia is strongly competitive, rather than devoting resources and policy efforts to those activities that Australia is facing declining competitiveness – such as some manufacturing sectors.

The escalation of globalisation through telecommunications and transport development has also been a key driver encouraging the assessment of competitiveness, as the more markets are opened up to
external competition, the more firms are impacted when their competitiveness declines. In reality, globalisation means that the primary role of government is to establish and foster the conditions for firms in an economy so that they can compete effectively with the rest of the world (Hawkins, 2006).

However, in some cases, indices of competitiveness that compare prices and costs in one country with those of another suffer from conceptual and measurement problems and may be of limited value. This is because the linkages between competitiveness, trade and economic growth are not easy to disentangle, particularly from one year to the next. In Australia’s case, most commentators would agree that the Australian economy has become more competitive since the early 1980s, yet they would find it hard to say by how much (Hawkins, 2006).

In the process of assessing the competitiveness of firms and nations there is also a need to take into account each nation’s economic characteristics. This is because the growth in living standards, and thus competitiveness, for countries with very little international trade is determined almost entirely by domestic factors. This means that the living standards of a less trade dependent nation primarily reflect the rate of domestic productivity growth and not the rate of that nation’s productivity growth relative to other countries (Krugman, 1994).

There have been three concerns raised about the risks of governments and others using the results of competitiveness assessments inappropriately. These are:

1. it could result in wasteful spending of government money supposedly to enhance a nation’s competitiveness,
2. it could lead to protectionism and trade wars, and
3. it could result in bad public policy on a spectrum of important issues (Krugman, 1994).

This caution serves as a reminder that competitiveness assessments are a useful tool to better inform decision-making, but are inevitably imperfect in their makeup and unable to incorporate all the possible factors that may impact on a firm or nation’s relative competitiveness.

The risks identified above serve as a warning of the importance of avoiding a simplistic approach to competitiveness assessments, whereby a series of indicators are compiled into an index number, which number then becomes the focus of discussion. While such numbers invariably attract media commentary due to their simplicity, they may provide little guidance about policy or other actions that might improve actual competitiveness (as distinct from the competitiveness score), and in particular do not convey any sense of the combination of policy and non-policy factors that might be important to future competitiveness.

This highlights the importance of validating a selected competitiveness assessment process or indicators against actual performance, in order to ensure that the factors or measures being used can be demonstrated to be appropriate and robust.

**Assessing agricultural competitiveness**

Research and analysis of agricultural sector competitiveness is less comprehensive than the work that has been carried out to assess competitiveness at a national economy level.

There are several possible reasons for this. One is that agriculture has been widely acknowledged to be one of the most trade-protected economic sectors globally, and therefore the notion of international competitiveness has historically not been one that has been of concern to many national agricultural policymakers. In fact, quite the opposite has been the case, despite the efforts of the Cairns Group of agricultural exporting nations. Many governments have historically focused on policies to protect their agricultural sector from international competition, rather than seeking ways to make it more competitive.
A second possible reason is that the availability of comparable national agricultural statistics has been somewhat patchy and limited statistical information available at the level of detail likely to be needed to conduct meaningful comparisons, especially between developed and developing nations.

The freeing-up of global agricultural trade that has occurred gradually over the last two decades and in particular post the global financial crisis means that the need for agricultural policymakers to consider agricultural competitiveness is now likely to be becoming more important.

Reasons for assessing agricultural competitiveness may include analysing the potential for a national agriculture sector to generate economic growth especially through exports, considering the impact of specific impediments to agricultural growth, or analysing the need for specific regional support policies in regions dependent on agriculture.

In some circumstances, agricultural competitiveness analysis focuses mainly on price or cost competitiveness, while the non-price component of firms’ or farms’ competitiveness (product differentiation, quality, design, novelty, reputation and reliability) which are also an important aspect in gaining market share and sustaining profits, are often forgotten (Latruffe, 2014).

Assessing agricultural competitiveness may also be a way to increase policymaker focus on the operational environment for agricultural growth and competitiveness. Generally, this type of analysis primarily relates to agricultural development objectives such as poverty alleviation, food security and nutrition, prosperity of small farmers, social equity, productivity growth and environmental sustainability in agriculture (Diaz-Bonilla et al., 2014).

**Methodologies used for assessing competitiveness**

This section of the literature review provides an overview of some of the different competitiveness assessment systems used internationally, some of which are designed to assess the competitiveness of a national economy, and some of which are more specific to a sector such as agriculture.

**Assessing national competitiveness**

One of the most well-known competitiveness scoring systems used internationally is the Global Competitiveness Index (GCI) published annually by the World Economic Forum. The GCI identifies 12 ‘pillars of competitiveness’ (composite factors) that are considered significant in comparing the relative competitiveness of nations. Using a number of specific quantifiable indicators and qualitative information from surveys of business leaders, a score is allocated for each of these pillars for each nation, and used to compile a composite ‘competitiveness index’ which is referred to as the GCI. It is published annually and provides a comparison of the assessed competitiveness, and changes in the relative competitiveness of 144 nations. The twelve GCI pillars are organised into three sub-indexes, each critical to a particular stage of development. These are as follows;

**Stage 1: Basic Requirements**

1. Institutions
2. Infrastructure
3. Macroeconomic environment
4. Health and primary education

**Stage 2: efficiency enhancers**

5. Higher education and training
6. Goods market efficiency
7. Labour market efficiency
8. Financial market development
9. Technological readiness
10. Market size
Stage 3: innovation and sophistication
11 Business sophistication
12 Research & Development Innovation (Schwab, 2014).

The GCI is structured in a manner that recognises that different factors are more or less significant depending on the stage of development of a nation. As explained in the GCI documentation;

“In line with well-known economic theory of stages of development, the GCI assumes that, in the first stage, the economy is factor-driven and countries compete based on their factor endowments—primarily unskilled labour and natural resources. Companies compete on the basis of price and sell basic products or commodities, with their low productivity reflected in low wages. Maintaining competitiveness at this stage of development hinges primarily on well-functioning public and private institutions (pillar 1), a well-developed infrastructure (pillar 2), a stable macroeconomic environment (pillar 3), and a healthy workforce that has received at least a basic education (pillar 4).

As a country becomes more competitive, productivity will increase and wages will rise with advancing development. Countries will then move into the efficiency-driven stage of development, when they must begin to develop more efficient production processes and increase product quality because wages have risen and they cannot increase prices. At this point, competitiveness is increasingly driven by higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labour markets (pillar 7), developed financial markets (pillar 8), the ability to harness the benefits of existing technologies (pillar 9), and a large domestic or foreign market (pillar 10).

Finally, as countries move into the innovation-driven stage, wages will have risen by so much that they are able to sustain those higher wages and the associated standard of living only if their businesses are able to compete with new and unique products. At this stage, companies must compete by producing new and different goods using the most sophisticated production processes (pillar 11) and by innovating new ones (pillar 12).

The GCI takes the stages of development into account by attributing higher relative weights to those pillars that are more relevant for an economy given its particular stage of development. That is, although all 12 pillars matter to a certain extent for all countries, the relative importance of each one depends on a country’s particular stage of development. To implement this concept, the pillars are organized into three subindexes, each critical to a particular stage of development.” (Schwab, 2014)

The 12 composite factors are measured by a range of indicators which include survey responses from business leaders and objective statistics (see Table 1).

The survey responses within the GCI Executive Opinion Survey (EOS) are the dominant indicators used for scoring competitiveness, as they determine around 67% of the overall score. The EOS process is made possible through the collaboration and dedication of a network of over 160 Partner Institutions worldwide. The Partner Institutions not only coordinate the EOS, they also communicate the results of the GCI at the national level (Schwab, 2014).
Table 1: Pillars of the Global Competitiveness Index and the relevant indicators

<table>
<thead>
<tr>
<th>pillar</th>
<th>requirements</th>
<th>indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st pillar: Institutions</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>A. Public institutions</td>
<td>Property right; 102 Intellectual property protection</td>
<td></td>
</tr>
<tr>
<td>2. Ethics and corruption</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>3. Unpaid work</td>
<td>166 Judicial independence; 177 Freedom to conduct business; 178 Protection of investors</td>
<td></td>
</tr>
<tr>
<td>4. Government effi ciency</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>5. Government goods</td>
<td>106 Business costs of electricity; 107 Business costs of transport; 113 Organised crime</td>
<td></td>
</tr>
<tr>
<td>6. Transparency of government expenditure</td>
<td>114</td>
<td></td>
</tr>
</tbody>
</table>
includes over 140 questions. Importantly, the EOS largely influences the international coverage of the assessment, whereby an economy will not be included in the GCI if the EOS cannot be conducted.

The GCI uses objective statistics such as enrolment rates, government debt, budget deficit and life expectancy. These data are obtained from internationally recognised agencies, notably the United Nations Educational Scientific and Cultural Organization (UNESCO), the International Monetary Fund (IMF) and the World Health Organization (WHO). The development of the GCI framework also engages the members of an advisory board.

The annual Global Competitiveness Report of the results of the GCI provides technical notes and sources which are complemented by data tables that include additional information for all indicators used in assessing competitiveness. The Global Competitiveness Report states that the data used in the GCI represent the best available estimates from various national authorities, international agencies and private sources at the time the GCI was prepared (Schwab, 2014).

The Institute of Management Development (IMD), based in Switzerland, also compiles and publishes an international competitiveness assessment report. The IMD competitiveness assessment report, which was first published in 1989, initially ranked the international competitiveness of 32 nations. Since that time, the number of countries involved in the ranking process has grown to sixty.

In 1996, the IMD created the World Competitiveness Yearbook (WCY) and the methodology that was developed at that time involved a five year time series which covered eight main competitiveness factors. In 2001, the methodology for assessing WCY national rankings was revised and the criteria were grouped into four main competitiveness factors instead of eight. The four main competitiveness factors for assessing the WCY national rankings currently include economic performance, government efficiency, business efficiency and infrastructure.

These four competitiveness factors are further divided into 20 sub-factors and for each of these there are multiple indicators (over 300 in total). Each sub-factor, independent of the number of indicators used to assess it, has the same weight (5%) in the overall ranking of nations (IMD, 2014). The WCY national rankings are calculated using both hard data, such as statistics on GDP, and soft data, such as survey responses from competent managers.

The hard data used in the WCY competitiveness assessment process makes up 67% of the overall weighting of factors used in calculating competitiveness ranking, while the soft – survey derived - data make up 33% of the weighting of the ranking. The hard data are obtained from international organisations, private institutions and national sources through the IMD network of Partner Institutes. The soft data are collected from a survey each year that asks business executives in top or middle management to assess the situation in their own country by responding to a questionnaire (IMD, 2014).

Methods used for assessing competitiveness at the regional level have generally been similar to international competitiveness scoring systems such as the GCI and WCY national rankings.

The European Commission, in the development of the Regional Competitiveness Index (RCI) for the EU, identified eleven competitiveness factors grouped in three sub-indexes (relevant to nations in different development stages), which are listed below.

The relevant indicators applied in stage one of the RCI assessment are considered strictly necessary for the basic functioning of any economy and cover aspects like unskilled or low skilled labour force, infrastructures, quality of governance and public health, which are also important economic and social determinants.

The relevant indicators applied in stage two assess the socio-economic environment, including the availability of a skilled labour force and the structure of the labour market. The relevant indicators
applied in stage three assess the level of technology and innovation. Those nations scoring highest in these are expected to have the most competitive economy (Annoni and Dijkstra, 2013).

**Stage one: basic**
1. Quality of institutions,
2. Macro-economic stability,
3. Infrastructure,
4. Health,
5. Quality of primary and secondary education,

**Stage two: efficiency**
6. Higher education and lifelong learning,
7. Labour market efficiency,
8. Market size,

**Stage three: innovation**
9. Technological readiness,
10. Business sophistication, and

The distribution of the three sub-index results are aggregated using a weighted linear function with weights depending on the stage of development of the specific region in question (see Table 2).

*Table 2: Regional Competitive Index 2013 weighting system*

<table>
<thead>
<tr>
<th>GDP per head in EU</th>
<th>DEV. STAGE</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Basic</strong></td>
</tr>
<tr>
<td>&lt;50</td>
<td>1</td>
<td>35.00%</td>
</tr>
<tr>
<td>[50-75]</td>
<td>2</td>
<td>31.25%</td>
</tr>
<tr>
<td>[75-90]</td>
<td>3</td>
<td>27.50%</td>
</tr>
<tr>
<td>[90-110]</td>
<td>4</td>
<td>23.75%</td>
</tr>
<tr>
<td>&gt;=110</td>
<td>5</td>
<td>20.00%</td>
</tr>
</tbody>
</table>

*Source Annoni & Dijkstra, 2013*

A number of private-sector organisations have also developed competitiveness assessment processes and tools, some of which have been reported as part of larger projects.

McKinsey Australia, which is part of the global management-consulting firm McKinsey & Company, have proposed two ways of assessing competitiveness. The first method assesses how a nation such as Australia actually performs in global markets using two outcome measures, which are:
1. export to import ratio, and
2. export share growth (Lydon et al., 2014).

The second method utilises measures of labour productivity (relative labour productivity) and input cost per hour worked (input cost efficiency) within specific sectors of a national economy, and then compares these between nations using a single nation (in one case the USA) as the benchmark.

Relative labour productivity is a measure of the value created per hour worked. It can be calculated for specific economic sectors by dividing Gross Value Added (GVA) by total hours worked. Relative input cost efficiency is calculated by dividing total input costs per hour worked. Relative input cost efficiency includes labour, services, materials, energy and capital, weighted by usage for each sector. (Lydon et al., 2014)
This research highlighted several technical limitations to this approach to competitiveness assessment. These include the need to allocate sector groupings, the need to consider the impact of intra-sector productivity and cost differences, the choice of a benchmark, the complexities associated with partial productivity measures, and issues associated with exchange rates and measurement error.

An alternative approach has been utilised by Deloitte Australia, which has reported the results of an assessment of Australia’s economic growth potential and sectorial advantages. To assess growth potential, Deloitte used as a benchmark projections of global gross domestic product (GGDP) growth for a range of industry sectors to 2033. The industry sectors were then grouped into three categories as follows:

1. those that are projected to grow at least 10% faster than GGDP,
2. those that are projected to grow at close to GGDP, and
3. those that are projected to grow at least 10% slower than GGDP.

The resultant ranking over time implied global growth (in purchasing power parity terms) is consistent with the global 10-year average from Consensus Economics (Deloitte Australia, 2013). The projections for each sector also made assumptions about key market drivers of each sector globally, including:

- urbanisation rates
- the rise of the middle class in emerging economies
- the impact of environmental concerns
- population ageing, and
- the pace of global growth (Deloitte Australia, 2013).

To assess the sectorial advantages, Deloitte Australia identified nine relevant indicators. These indicators were allocated relative weights and were also grouped into three categories, which include:

1. Natural resources, proximity to Asia and revealed comparative advantage were assumed to be related. These factors combined drive about 33% of the total competitiveness score.
2. Cost competitiveness, regulatory competitiveness and exchange rate were assumed to be related. These factors combined drive just under 50% of the total competitiveness score.
3. Educational attainment, site-specific factors and relative productivity were the remaining indicators. Relative productivity carried the largest degree of advantage in this group.

Based on this methodology, the Deloitte research identified the factors that were considered to be sources of Australian competitive advantage, and the extent of the advantage they conferred. The results of this analysis are displayed in Figure 1.

These results highlight one of the fundamental problems that emerges from many competitiveness assessment processes, in that the indicators selected for inclusion are a mix of factor endowments (for example natural resources and proximity to Asia) and other factors (for example cost competitiveness, relative productivity, exchange rates and revealed comparative advantage) that are partially a result of these factor endowments. The fact that a number of these are related raises questions about the validity of combining them as part of an overall competitiveness assessment. In addition, a number of these indicators relate to matters that cannot be modified by policymakers, so depending on the purpose for which the assessment process is being used the results may provide little help for policymakers facing choices about future policy settings.
Assessing regional competitiveness

In Australia, the Regional Australia Institute (RAI) has recently completed research to investigate factors contributing to the competitiveness of Australia’s non-metropolitan regions. In developing an index of regional competitiveness, the RAI drew heavily on both the GCI and the RCI to identify ten factors considered important in determining the competitiveness of specific regions, and therefore suitable for inclusion in an index of regional competitiveness. The ten factors included in the RAI index were as follows:

1. Institutions,
2. Infrastructure,
3. Macroeconomic conditions,
4. Human capital,
5. Labour market efficiency,
6. Technological readiness,
7. Business sophistication,
8. Innovation,
9. Market size and
10. Natural resources (RAI, 2013).

The resulting regional competitiveness index (known as ‘[In] Sight’) consists of 59 measurable indicators of competitiveness for the ten factors. The indicators and associated measurement criterion largely focused on the economic drivers that determine longer term competitiveness. Together the competitiveness factors and indicators are claimed to capture a region’s inherent ability to attract and utilise capital and labour efficiently to maintain and improve economic and social prosperity (RAI, 2013).

The [In] Sight competitiveness index functions as an interactive tool which allows users to make comparisons between regions. The index tool can reveal vital information about the distribution of
underperforming regions and this information can then be used as an evidence base with which to establish both short and long term policy priorities (RAI, 2013).

**Assessing agricultural competitiveness**

Assessments of the competitiveness of national economic sectors such as the agriculture can generally be made utilising either of two disciplines, which are:

1. neoclassical economics which focuses on trade success and which measures competitiveness with the real exchange rate, comparative advantage indices, and export or import indices, and
2. the strategic management school which places emphasis on the firm’s structure and strategy (Latruffe, 2014).

Trade measures of competitiveness include real effective exchange rates, purchasing power parities, revealed comparative advantage (sometimes called the Balassa index or relative export advantage/RXA) and export measures, such as the simple indicator of export market shares (EMS). These measures of competitiveness can also be expressed in terms of quantity or value, depending on the purpose of the assessment. (Latruffe, 2014).

Strategic management measures of competitiveness includes the domestic resource costs (DRC) ratio and the social cost-benefit ratio (SCB). The DRC reveals whether the domestic production of a specific good is internationally competitive when the opportunity costs of domestic production are less than the value added of output at world prices. The SCB reveals whether the domestic production is competitive when total input costs are less than the revenue derived from the good produced. The SCB also includes profitability which is related not only to costs of production but also to revenue (Latruffe, 2014).

Measures of competitiveness are generally of a static nature, yet the conditions in which firms and farms operate are constantly changing, and therefore it can be expected that their competitiveness does too (Latruffe, 2014). Moreover, competitiveness is generally defined as the ability to sustain a profitable enterprise over the long term, or in a sustainable way.

Measurement of the evolution of competitiveness measures may thus be preferred to annual measurements. A second point to stress is that competitiveness should be measured with respect to a benchmark as it is a relative concept, which means that firms (or farms) must be compared with each other, or nations with each other (Latruffe, 2014).

For a meaningful policy dialogue with informed policy choices, it is also important to identify the drivers of competitiveness and to determine the relationship between the drivers and the state of competitiveness of the sector under study. For competitiveness studies focussed on trade performance, this requires a significant investment to collect the relevant secondary data. Once the data availability issue is addressed, one can examine the determinants of competitiveness using an econometric model in which the competitiveness scores are regressed on a set of explanatory variables (Sarker and Ratnasena, 2014).

This approach has been widely used in assessing efficiency, productivity, cost competitiveness, effects of policy reforms and effects of farm size and other structural characteristics (Sarker & Ratnasena, 2014). However, a slightly different approach to competitiveness can be taken by narrowing the investigation to the comparative advantage of agriculture and food sectors. This can be done by using either Revealed Comparative Advantage (RCA) or Normalised RCA (NRCA) measures in a regression framework to determine the underlying drivers of comparative advantage in specific circumstances (see Tables 3 & 4).
Table 3: Alternative approaches to measure the Revealed Comparative Advantage

<table>
<thead>
<tr>
<th>Measure of Comparative Advantage</th>
<th>Formula</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balassa’s Index of Revealed Comparative Advantage (BRCA)</td>
<td>$RCA_{ij}^j = \frac{(X_j^A/X_i^A) / (X_j^{REF}/X_i^{REF})}$</td>
<td>- RCA only signifies whether or not a country has comparative advantage in a commodity (Hillman, 1980; Yeats, 1985)</td>
<td>- The magnitude of the RCA has neither the ordinal property nor the cardinal property (Yeats 1985). It can generate inconsistent and misleading results.</td>
</tr>
<tr>
<td></td>
<td>Where, $X_j^A$ = the export of sector $j$ in country A</td>
<td>- Preferred by policymakers who want to identify comparative advantage sectors without considering their economic impacts</td>
<td>- The distribution of the RCAs around the mean is asymmetric.</td>
</tr>
<tr>
<td></td>
<td>$X_i^A$ = the total export of sector $i$ in country A</td>
<td>- Deriving the distribution of the standard RCA is further complicated by its dependence on the number of countries in the analysis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$X_j^{REF}$ = the total export of sector $j$ of the reference countries</td>
<td>- The mean of RCA is unstable and larger than the theoretically expected value of 1. Therefore, economic interpretation of its mean problematic.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$X_i^{REF}$ = the total export of the reference countries</td>
<td>Make Balassa’s RCA symmetrical</td>
<td>A commodity with zero export would be undefined.</td>
</tr>
<tr>
<td>Logarithm of Balassa’s RCA (Volthath, 1991)</td>
<td>$SRCA_{ij}^j = (RCA_{ij}^j - 1)/\ln(RCA_{ij}^j + 1)$</td>
<td>- The distribution of SRCA scores symmetrically ranges from -1+1 with 0 being the competitive—advantage-neutral point.</td>
<td>However this symmetry comes at a cost as the transformation makes the economic interpretation of the SRCA index not as clear as the RCA index (Benedicta and Tamber, 2001).</td>
</tr>
<tr>
<td>Symmetrical RCA Index (SRCA) (Laursen, 1998)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighted RCA (WRCA) (Proudman and Redding, 1998)</td>
<td>$WRCA_{ij} = \frac{RCA_{ij}}{\left(\frac{1}{N} \sum_{k=1}^{N} RCA_{ij}\right)}$</td>
<td>- The transformation results in a time-invariant mean of N for an individual country and helps to establish the WRCA index’s comparability within an individual country.</td>
<td>Does not correct the asymmetric problem of the RCA index.</td>
</tr>
<tr>
<td></td>
<td>Where N is the number of commodities</td>
<td>The transformation makes the comparative advantage neutral point sensitive to the classification of commodities (Benedicta and Tamber, 2001).</td>
<td></td>
</tr>
<tr>
<td>Additive RCA (ARCA) (Hoen and Oosterhaven, 2006)</td>
<td>$ARCA_{ij}^j = \frac{X_j^A}{X_i^A} - \frac{X_j^{REF}}{X_i^{REF}}$</td>
<td></td>
<td>Does not reveal whether or not a country ‘as a whole’ has a relatively specialized export package.</td>
</tr>
<tr>
<td></td>
<td>Interpretation: ARCA = 0 if the export share of sector j in country A is equal to that of the reference countries. ARCA &gt; 0 if country A has a “revealed comparative advantage” in sector j and vice versa. The ARCA for an individual sector, with country A excluded from the group of reference countries, ranges from exactly -1 to exactly +1.</td>
<td></td>
<td>However the sum of all countries’ ARCA scores for an individual commodity generally is not a constant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The distribution of the ARCA is centered symmetrically around its stable mean.</td>
<td>Finally, ARCA’s comparability across country is not as well established as its comparability across commodities.</td>
</tr>
</tbody>
</table>

Source: Sarker & Ratnasena, 2014
The most widely used measure of the international competitiveness of a sector or a country has been RCA (Sarker, 2014). However, the NRCA method has also been used to measure international competitiveness by making a comparison across sectors and over time in the form of an index.

The NRCA index measures the degree to which the specific type of exports from a country deviates from its comparative advantage neutral line in terms of its relative scale with respect to the world market. Thus, the NRCA method provides a more reasonable indication of the underlying comparative advantage over time when compared to the RCA method (Sarker, 2014).

The OECD Food, Agriculture and Fisheries division have developed a preliminary index of the enabling environment for agricultural growth and development.

The development of the preliminary Agricultural Growth Enabling Index (AGEI) involved three steps. First a review of literature was undertaken to assist with identifying key determinants of economic growth, agricultural growth and competitiveness. The review of literature also identified existing indicators which have been used as an indicator of these determinants.

The second step proposed a new typology to structure the components of the enabling environment for agricultural growth and competitiveness (see Table 5). The third and final step involved trialling a preliminary index methodology with a select set of 20 emerging and developing countries (Diaz-Bonilla et al., 2014).

Source: Sarker & Ratnasena, 2014
<table>
<thead>
<tr>
<th>Government measures and initiatives</th>
<th>Farmers (from near landless to commercial farmers)</th>
<th>Rural and regional economy</th>
<th>Food and agricultural value chains (non-farm components)</th>
<th>General economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture policies</td>
<td>Per cent of food sector firms offering formal training Per cent of firms offering in-house training</td>
<td>Per cent of food sector firms offering in-house training</td>
<td>Per cent of food sector firms offering in-house training</td>
<td>Agriculture and non-agriculture terms of trade (national accounts)</td>
</tr>
<tr>
<td>General services</td>
<td>GSSP (GDP), selected components</td>
<td>GSSP (GDP), selected components</td>
<td>GSSP (GDP), selected components</td>
<td>Institutions (GDP)</td>
</tr>
<tr>
<td>Institutions</td>
<td>Food safety, health, energy (GFSI 1 to 1) Productivity, corruption (food sector firms (ES WP))</td>
<td>Infrastructure (GDP), Technical infrastructure (GDP)</td>
<td>Infrastructure (GDP), Technical infrastructure (GDP)</td>
<td>Regulatory regimes (GDP)</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Private crop storage (GFSI 2.3.1) Agricultural irrigation (GWI)</td>
<td>Agriculture and infrastructure (GFSI 2.3), improved land use water source (infrastructure)</td>
<td>Energy and water transportation indicators for food sector firms (ES WP)</td>
<td>Infrastructure (GDP), Technical infrastructure (GDP)</td>
</tr>
<tr>
<td>Macroeconomic environment</td>
<td>Total public expenditure on agriculture as per cent of agriculture GDP (GDP)</td>
<td>Provincial budget for economic activities (GDP)</td>
<td>Provincial budget for economic activities (GDP)</td>
<td>Macroeconomic environment (GDP)</td>
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<tr>
<td>Health and education</td>
<td>Literacy (incidence) (UNESCO)</td>
<td>(UNESCO)</td>
<td>(UNESCO)</td>
<td>Health and education (GDP)</td>
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<tr>
<td>Goods markets</td>
<td>Textile and other business indicators for food sector firms (ES WP)</td>
<td>Textile and other business indicators for food sector firms (ES WP)</td>
<td>Textile and other business indicators for food sector firms (ES WP)</td>
<td>Textile and other business indicators for food sector firms (ES WP)</td>
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<tr>
<td>Land and water markets</td>
<td>Arable land resources (GWI)</td>
<td>Land and water resources (GWI)</td>
<td>Land and water resources (GWI)</td>
<td>Land and water resources (GWI)</td>
</tr>
<tr>
<td>Labour markets</td>
<td>Employment in agriculture, Child mortality in agriculture (GWI)</td>
<td>Proportion of workers in food sector firms offered formal training</td>
<td>Proportion of workers in food sector firms offered formal training</td>
<td>Labour market outcomes (GDP)</td>
</tr>
<tr>
<td>Financial markets</td>
<td>Access to finance by farmers (GFSI 1.1)</td>
<td>Per cent of food sector firms financed by banks</td>
<td>Per cent of food sector firms financed by banks</td>
<td>Financial market development (GDP)</td>
</tr>
<tr>
<td>Higher education / Technology / Innovation</td>
<td>Public agriculture R&amp;D expenditure as per cent of agriculture GDP (GWI)</td>
<td>Per cent of food sector firms with internationally recognized quality certification</td>
<td>Per cent of food sector firms with internationally recognized quality certification</td>
<td>Higher education and training (GDP)</td>
</tr>
<tr>
<td>Environment</td>
<td>Change in forest area Population living on degraded land (GDP)</td>
<td>Greenhouse gas emissions, impact of natural disasters, Natural resource depletion (GDP)</td>
<td>Greenhouse gas emissions, impact of natural disasters, Natural resource depletion (GDP)</td>
<td>Greenhouse gas emissions, impact of natural disasters, Natural resource depletion (GDP)</td>
</tr>
</tbody>
</table>

Source: OECD, 2014
The development of the preliminary AGEI identified two main groupings of factors making up the enabling environment for agricultural growth and competitiveness. These were:

1. the various categories of government measures and activities affecting the sector’s performance, and
2. the effects of these measures and activities across four levels of the economy. These levels include agricultural producers, the rural/ regional economy, agricultural value chains, and the general economy - where among other things, final demand is determined (Diaz-Bonilla et al., 2014).

Two important enablers of growth in the agriculture sector were identified during the development of the preliminary AGEI. These were:

1. sustained growth on the demand side such as growth in the non-agriculture economy and exports, and
2. the strengthening of the rural non-farm sector and the value chains that link agricultural supply with demand (Diaz-Bonilla et al., 2014).

The work associated with the development of the preliminary AGEI found that some of the competitiveness factors were relatively well quantified by available data and studies, particularly for the general economy and the agricultural sector at the farm level. However, for rural regions and agricultural value chains it was found that there are significant deficiencies in available data.

Despite the data deficiencies which imposed some limitations, the preliminary AGEI has been developed to a stage whereby it is comprised of four groups of factors, with 40% of the weighting of factors in the overall index allocated to agriculture/rural factors and 20% each to broader economy-wide governance, capital availability and market operation (see Table 6).

Using this methodology, the preliminary results identified that the AGEI incorporated information relevant to the enabling environment for agricultural growth and competitiveness in a parsimonious manner largely consistent with more in-depth studies of the selected countries (Diaz-Bonilla et al., 2014).

Table 6: Structure of the preliminary Agriculture Growth Enabling Index

<table>
<thead>
<tr>
<th>Component</th>
<th>Sub-Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance (20% weight; equal shares on each subcomponent)</td>
<td>Macro (GCI P3)</td>
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<tr>
<td>Institutions (GCI P1)</td>
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<tr>
<td>Political stability affecting food security (GFSI 2.5)</td>
<td></td>
</tr>
<tr>
<td>Capital (20% weight; equal shares on each subcomponent)</td>
<td>Health/Education (GCI P4) (human capital)</td>
</tr>
<tr>
<td>Presence of food safety net (GFSI 1.5) (human capital)</td>
<td></td>
</tr>
<tr>
<td>Infrastructure (GCI P2) (physical capital)</td>
<td></td>
</tr>
<tr>
<td>Markets (20% weight; equal shares on each subcomponent)</td>
<td>Goods market operations (GCI P6)</td>
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<tr>
<td>Labour market operations (GCI P7)</td>
<td></td>
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<tr>
<td>Financial market operations (GCI P8)</td>
<td></td>
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<tr>
<td>Agriculture-Rural (20% weight on each pillar; equal shares on each subcomponent within a pillar with the exception of double weight on public agricultural R&amp;D expenditures)</td>
<td>Pillar A:</td>
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<tr>
<td>Access to financing for farmers (GFSI 1.6)</td>
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<tr>
<td>Public agricultural R&amp;D expenditure as a percent of agricultural GDP (IFPRI)</td>
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<td>Land tenure rights and access (MICC)</td>
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<td>Pillar B:</td>
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<tr>
<td>Agriculture Infrastructure (GFSI 2.3)</td>
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<tr>
<td>Index of intensification (authors based on WDI)</td>
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<td>Index of availability of land and water (authors based on WDI)</td>
<td></td>
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</tbody>
</table>

Country coverage:
Brazil, Chile, China, Colombia, Egypt, Ethiopia, India, Indonesia, Kazakhstan, Kenya, Mexico, Pakistan, Russia, Senegal, S. Africa, Tanzania, Thailand, Turkey, Ukraine, Viet Nam

Source: OECD, 2014
There has also been some research aimed at considering agricultural competitiveness at the farm level, as distinct from the agriculture sector level.

The OECD Network for Farm-level Analysis have assessed international farm performance data. The members of the network have established a cross-country database with a harmonized definition of population and variables. This allows the OECD to compare the distribution of four economic performance indicators across nine participating countries or regions for selected farm types. The four economic performance indicators involved are;

1. output and input ratio,
2. net operating income per unit of labour,
3. net operating income per ha of land, and
4. net operating income per dollar of net worth (Kimura and Le Thi, 2013).

The OECD also compared the characteristics of high and low performing groups across nations by benchmarking the performance of “frontier” (high performance) farms and “catching up” (below average) farms within a nation as well as across nations. The competitiveness factors were analysed to statistically identify the principal factors associated with high farm performance. Each competitiveness factor consisted of a vector of farm characteristics variables (e.g. farm size, age and education). This statistical method provided an advantage in reducing the number of farm characteristics to a few principal factors so that the relative importance of the competitiveness factors reflected those of high performance farms (Kimura & Le Thi, 2013).

The analysis identified two categories of determinants which influence farm competitiveness, which are determinants over which farmers or firms have control, and determinants over which they have no control. (Latruffe, 2014).

Determinants over which farmers or firms have control include structural characteristics such as size, organisational type and level of indebtedness as well as social capital such as the farmer’s age and educational level. Determinants beyond farm control include factor endowments and demand conditions, government intervention and public expenditure in research, extension and infrastructure, as well as the location of the farm activities. However, the researchers noted there is a problem with assessing the impact of government intervention because it may change competitiveness superficially without increasing real competitiveness (Latruffe, 2014).

The European Commission has considered the competitiveness of the food industry in the EU, which is another competitiveness assessment closely related to the agricultural sector. The food industry competitiveness assessment was based on five factors, including;

1. Growth in real value added of a specific industry in the total food industry. This reflects the competition for production factors between different industries within a country.
2. Growth in the Balassa index. This index reflects the export specialisation level in one category of goods from one country.
3. Growth in export share (absolute deviation) on the world market. This performance indicator reflects the outcome of the competitive process. The extra-trade determines this growth for the EU.
4. Growth in real labour productivity. This affects the unit labour costs and relative prices.
5. Growth in real value added reflects the industrial dynamism (Wijnands et al., 2006).

The terminology the European Commission’s used to qualify competitiveness assessment results is taken from the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis approach (see Figure 2). The main data sources used were official statistical agencies such as Eurostat (Structural business statistics), the United Nations (Comtrade), the UN Food and Agriculture Organization (FAO) (supply and utilisation accounts) and from national agencies such as the US Census Bureau.

The selection of global competitors for comparison was based on an analysis of the export market shares. This identified as benchmark nations the USA, Australia, Brazil and Canada. China was noted
as an important emerging food exporter, but was not included in the analysis due to a lack of reliable enterprise statistics for that nation (Wijnands et al., 2006).

Using this analysis, the EU was able to rank each nation for each category, and also to calculate an overall competitiveness ranking for each nation’s food industry, the results of which are displayed in figure 2. It should be noted that this analysis involved the entire food sector, not just the farm sector.

**Figure 2: Competitiveness of the EU food industry**

*Source: Wijnands et al., 2006*

**Assessing long term competitiveness**

This section of the literature review looks at factors that may influence the longer term potential for competitiveness. This includes a brief overview of some factors impacting on the long term competitiveness of agricultural sector participants.

Productivity and efficiency are often cited as key indicators or measures of competitiveness, and the European Commission considers productivity as the most reliable indicator of competitiveness over the long term (Bleischwitz et al., 2007).

The GCI has been used to assess the level of productivity of an economy, which determines its long-term growth potential (Schwab, 2014). Productivity growth in agriculture, which reflects increases in the efficiency of production processes overtime, is a key determinant of farm profitability and an important mechanism for maintaining the international competitiveness of Australian agriculture (Gray et al., 2011).

Apart from productivity and efficiency, competitiveness factors that impact on the agricultural sector’s longer term potential also include indicators such as available land for agricultural development and unrealised productivity potential.

For example, the world’s arable land use is expected to increase by 0.10% per annum from 2005 through till 2050 (see Table 8). The regions that have been identified as potentially increasing arable land use the fastest include sub-Saharan Africa and Latin America. However, arable land expansion
will continue to be a significant factor in those developing countries and regions where the potential for expansion exists and the prevailing farming systems and more general demographic and socio-economic (e.g. political) conditions favour it (Bruinsma, 2009).

Data and projections used when modelling long term potential for arable land expansion indicate that industrial nations, including Australia, are projected to experience a reduction of 0.15% per annum in the availability of arable land over the period to 2050, in contrast to projected growth in the availability of arable land in developing nations. The ability of land-constrained or ‘fully-developed’ agricultural sectors to respond to increased demand will obviously be more limited, all other things being equal, than national agricultural sectors with expansion capacity. Depending on the metrics used to assess competitiveness, this could result in some national agricultural sectors appearing to be less competitive.

Table 7: Total arable land – data and projections

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<td>Sub-Saharan Africa</td>
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<td>Latin America</td>
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<td>Near East North Africa</td>
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<td>South Asia</td>
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<td>East Asia</td>
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<td>excl. China</td>
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<td>Developing countries</td>
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<td>excl. China and India</td>
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<td>Industrial countries</td>
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<td>Transition countries</td>
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<tr>
<td>World</td>
<td>1375</td>
<td>1571</td>
<td>1562</td>
<td>1602</td>
<td>1648</td>
<td>1673</td>
<td>0.31</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: Bruinsma, 2009

An additional factor to consider in assessing national agricultural competitiveness is the unrealised productivity potential that exists for a particular nation. A national agricultural sector where a large number of farms are already close to international productivity frontiers is unlikely to be able to achieve rapid growth, whereas a nation where many farms have unrealised productivity potential potentially has much more growth capacity available.

A simple example of this is evident in relation to wheat yield. Analysis conducted for the Food and Agriculture Organisation (FAO) of the UN (Bruinsma, 2009) produced national estimates of the amount of land suitable for rain-fed wheat production. The land was classified as either Very Suitable (VS), Suitable (S) or Moderately Suitable (MS), and based on that assessment, attainable yields were estimated (essentially the productivity frontier).

A comparison between attainable yields and actual averages over a five year period (see Table 9) identifies that some national wheat sectors (the UK, France and Denmark, for example) appear to be achieving close to attainable yields, whereas others have unrealised productivity potential, and thus farms in those nations have greater opportunities to enhance their competitiveness. Some caution is required with such assessments – for example the five years coincided with a significant drought event in Australia, which would have made the apparent gap between attainable and realised yields appear more significant.
Factors such as future land availability and unrealised productivity potential are difficult to quantify objectively, but are undoubtedly quite significant factors in the long-term competitiveness of a particular national agriculture sector.

Validation of competitiveness assessments

There are a range of different methodologies and approaches that have been used to compile competitiveness assessments at a national, regional and sectoral level, but these are of little benefit unless the results they produce are validated by the historic or subsequent performance of that nation, region or sector.

This section of the literature review provides an overview of the validation methods that have been used in the compilation and ongoing development of competitiveness assessments.

The GCI results published in the Global Competitiveness Report was one of the first attempts to support policymakers and business leaders in their efforts to formulate improved economic policies and institutional reforms. The Global Competitiveness Report highlights how an undertaking of this dimension was never expected to be perfect, but would of necessity require continual refinement and improvement over time.

Some assessments of the utility of the GCI in predicting national economic performance have not reached positive conclusions. For example, Lall (Lall 2001) concluded that the GCI has grave deficiencies. These included “that the definitions are too broad, the approach biased, the methodology flawed and inconsistent, and many measures (are) vague, redundant or wrongly calculated.” This research concluded that “competitiveness indices have weak theoretical and empirical foundations, and may be misleading for analytical and policy purposes.”

Other assessments have been less critical, although still questioning of the validity of the GCI methodology (Bowen and Moesen 2005, 2009). They found a reasonable correlation between national GCI scores and Gross National Income per capita, but quite poor correlation between national GCI scores and Gross Domestic Product growth rates. This suggests that national GCI scores may reflect past economic performance rather than providing an indication of future economic potential.
The annual GCI publication incorporates an analysis of the validity of the GCI. The most recent GCI publication reports that recent analysis of the GCI has identified that about 67% of the variation in GDP per capita can be explained by the results of the GCI (Schwab, 2014).

The GCI results have also been statistically tested by calculating the correlation between the GCI results and GDP growth once the conditional convergence effects (where growth rates of countries become closer over time) have been discounted. This validation method plots the GDP net-of-convergence growth rates against a natural log of the GCI score. This statistical test currently shows a positive and strong correlation, which it is argued confirms that the GCI is a good proxy for the level of productivity or competitiveness of a nation (Schwab, 2014).

In 2014, the WEF commenced a review of the GCI methodology. The review will be a two-year process which engages high-level experts in academia along with practitioners and business leaders to identify the improvements needed to capture the evolving nature of the drivers of competitiveness (Schwab, 2014).

At the agriculture sector level, the OECD’s analysis of the preliminary AGEI index indicated that, with caveats, the index has a positive correlation with observed agricultural value added per worker, both in relative levels and growth rates (Diaz-Bonilla et al., 2014).

Another means of assessing the utility of measures of competitiveness is to test whether they have predictive power (Hawkins, 2006). The competitiveness results for Japan and Switzerland provide a good example of assessment methods that have not displayed predictive power in the past. For example, Japan was ranked the world’s most competitive economy in 1990, just before its prolonged period of poor economic growth. Switzerland was ranked second at this time and also had a poor economic growth record in the 1990s (Hawkins, 2006).

An added complication in validating competitiveness assessments which compare nations is the role that currency exchange rates play in apparent differences in the performance of national economies, and sectors within those national economies. As a relevant example, irrespective of the relative competitiveness of the Australian agriculture sector, it has been rendered less internationally competitive over the past decade due to the relatively high exchange rate of the Australian dollar, courtesy of the boom in demand for Australian mineral and energy exports over this period.

The increasing role of the global supply chains of multinational corporations further complicates this issue, because of the challenges they create to the validity of standard formulas used in computing real effective exchange rates. Multinational corporations may choose to transfer agricultural goods across national borders for reasons such as a desire to better utilise processing capacity, rather than their innate competitiveness. As a consequence, many emerging market economies may appear to be maintaining goods competitiveness while losing overall competitiveness due to a relative increase in domestic factor costs or an appreciation of nominal exchange rates (Bayoumi et al., 2013).

In summary, the scoring system used to compare the competitiveness of nations, economic sectors or regions should be validated by correlating the relative results with a nation’s or region’s productivity growth rate. Productivity is considered the key indicator of long term national or regional competitiveness. Proxies for productivity, such as gross domestic product (GDP) per capita or GDP growth rates, can also be used to validate competitiveness indexes.
Discussion and conclusions from the literature

There are a number of international organisations such as WEF and IMD that have been assessing international competitiveness for several decades. These organisations have adjusted definitions of competitiveness over time, and utilise those definitions in measuring and comparing the level of productivity and prosperity of nations.

Government agencies have generally defined competitiveness in terms of citizens’ levels of prosperity relative to employment conditions and living standards of residents. Most also acknowledge that productivity growth is an important indicator of relative competitiveness, particularly over the longer term.

Economists and researchers are sometimes critical about the inconsistency and ambiguity of the concept of competitiveness. These concerns include that competitiveness is an elusive concept which economists try to avoid by narrowing the focus to relative cost competitiveness. There have also been concerns raised about decision-makers justifying or avoiding hard choices based on their presumed impact on measures of competitiveness, rather than their real impact.

Despite data limitations and concerns about misguided interpretations of results, researchers have generally concluded that competitiveness assessments can be helpful decision-support tools which assist in identifying strengths and weaknesses of a specific nation.

The methods used to assess competitiveness normally involve identifying the range of composite factors that are understood to be significant, and the relevant economic, social and environmental indicators that can best be used as a measure of those. While there is a growing body of knowledge and expertise associated with national competitiveness assessments, there is less knowledge and expertise associated with such assessments at the sectoral level – such as agriculture-sector competitiveness.

Part of the reason for this may be that the robustness and comprehensiveness of data generally declines at the sub-national level, making such sectoral assessments more difficult. A further reason may be that an economic sub-sector such as agriculture obviously has strong dependencies on national economy-wide factors (such as telecommunications, transport and infrastructure), making it difficult to determine whether competitiveness is being driven by factors that are external to or specific to the agriculture sector.

The OECD is perhaps the only organisation to have attempted to develop an assessment of national agriculture sector competitiveness. That research involved a study of agricultural competitiveness in the context of agricultural development objectives such as poverty alleviation, prosperity of small farmers, productivity growth and environmental sustainability. The OECD found that the best competitiveness scoring system was an approach that involves four composite factors including specific agricultural sector sub-factors, plus broader economy-wide governance, capital availability and market factors.

This approach to assessing agricultural competitiveness was developed by the OECD to help policy makers focus on the sectoral and economy-wide issues that require some improvement amongst developing nations, and it was acknowledged that the approach taken in the OECD work was ‘rudimentary’, but an important first step.

One of the challenges associated with extending the OECD approach to developed nation agriculture sectors arises from the learnings associated with the Global Competitiveness Index, detailed earlier. The experience gained in developing the GCI over an extended period has identified that the factors important to the relative competitiveness of developing nations are different to the factors that are important in the case of developed nations, and there is no reason to believe that this will be different when it comes to agriculture sector competitiveness. In the case of a developing nation with a relatively undeveloped agriculture sector, it would be anticipated that factors such as land tenure, and
access to machinery and technology would be important, whereas in the case of developed nations, these factors are generally universally accessible. This means that there will not likely be one set of factors, or a common allocation of weighting to factors, that will adequately provide an assessment of the relative competitiveness of both developed and developing nation agriculture sectors.

There has not been a substantial body of research carried out to examine the competitiveness of specific commodity sub-sectors within a national agriculture sector. There have been international researchers that have used the Normalised Real Comparative Advantage (NRCA) statistic as an indicator of commodity-specific competitiveness. The NRCA measures the degree to which a nation is more successful at exporting a specific commodity, compared to the performance of all other nations included in a comparison. This method provides an indication of the underlying national comparative advantage for a specific commodity and also identifies trends in the competitiveness of a nation in producing that commodity over time.

The review of literature identified three major concerns that have been raised by economists and researchers about some of the methods used to assess competitiveness.

First, international comparisons of prices may be useful for analysing the international competitiveness of a particular industry within a country, but it is less clear whether it is meaningful to talk about the competitiveness of an entire national economy (Hawkins, 2006). This is because the price of specific goods can vary between countries, even though there is a single international market price. In principle, a comparison could be done for unit labour costs (e.g. the ratio of wages to productivity) but given the difficulties involved in getting internationally consistent data on both wages and productivity, the measures of the ratio may be quite unreliable (Hawkins, 2006).

Secondly, there are concerns about real effective exchange rate measures that are generally cited relative to an arbitrarily chosen base year (Hawkins, 2006). Real effective exchange rates indicate whether an economy is becoming more or less competitive, but in some circumstances do not reflect an economies current level of competitiveness. Real effective exchange rates also tend to rise in economies which are innovative and successful, making their price competitiveness appear worse. This has meant that indices like the Big Mac index have not been overly helpful because Big Macs are not traded internationally (Hawkins, 2006). Nevertheless, if the same exercise was undertaken for a range of traded goods, this method could be weighted appropriately to derive an index of overall external price competitiveness.

Finally, questions have also been raised as to why the WEF and IMD both somewhat arbitrarily weight together a large number of variables – around 150 for the WEF and over 300 for the IMD (Hawkins, 2006). Both these indices use surveys of the opinions of business leaders for their own economies. Therefore, when business leaders are only asked for opinions on their own country, those countries with brash and confident leaders will poll better than those with more self-effacing or reflective leaders (Hawkins, 2006).

In the context of efforts to develop a relevant assessment process for the competitiveness of the Australian agriculture sector, there are a number of insights available from the efforts that have occurred to develop competitiveness assessments at a national scale.

An appropriate approach appears to involve the identification of critical factors thought likely to influence competitiveness, and then to utilise objective indicators for these in order to obtain valid and robust information about changes in those factors over time. Ideally, the significance of each of the factors or indicators should be weighted on the basis of an objective and statistically valid approach, although it is recognised that the limitations of data may make such a weighting approach problematical.

Equally important, however, is the need to validate any assessment process against objective past performance criteria. This highlights the desirability of utilising datasets that extend over a
considerable timeframe, given the understanding that exists of the long lag times associated with investments in factors such as agricultural research and development, for example.

It appears likely from earlier research that the combination of factors and weightings that are significant in assessing the competitiveness of agriculture sectors of developed nation economies will not be the same as those that are relevant to developing nation agriculture sectors, hence there will be a need to either only compare nations that are at a similar stage of development, or to construct the assessment process in a way that allows some variation in weightings allocated to nations at differing stages of development.

Finally, a key lesson from earlier efforts to develop competitiveness assessments is that there will undoubtedly be a need to change factors and indicators as learnings emerge, hence it will be important to retain some flexibility in the way the assessment process is constructed.
A trial agricultural competitiveness index

The preceding analysis has identified both the potential advantages and disadvantages of a competitiveness index developed specifically for a sector such as Australian agriculture. Noting the lessons arising from that analysis, the development of a competitiveness assessment process specifically for the agriculture sector (expressed ultimately in the form of a composite index) could provide a useful tool to encourage greater policymaker focus on factors likely to enhance the competitiveness of the sector. The utility of any process developed will ultimately depend on the extent to which it provides outcomes that are meaningful in terms of the competitiveness performance of national agriculture sectors.

In order to establish a methodology, the first step was to develop a list of those factors that are understood to be important in enhancing the performance of those farm businesses that make up the agriculture sector of a nation. At its most basic, businesses in the agriculture sector utilise a range of production factors, namely land (including water), labour, capital and technology (including a wide range of farm inputs), to produce plant or animal products which are then processed, transported and marketed to consumers either in a domestic or international market.

Relevant indicators of the competitiveness of a national agriculture sector are therefore most likely to be those associated with specific inputs and factors that are important at the farm level, and indicators associated with the wider business environment and the performance of the national economy.

The approach adopted for this trial was to identify potential indicators for a range of different nations. A limiting issue in relation to this process was the availability of consistent, time-series data for specific indicators for any national agriculture sectors included in the research. The lack of consistent national agricultural statistics means that, of necessity, the agriculture-sector indicators selected for inclusion in the competitiveness assessment need to be higher-order, aggregated indicators, rather than very specific indicators such as farm expenditure on chemical inputs or the educational status of the farm operator.

As discussed in relation to the learnings arising from the literature review, it was felt that for a proposed competitiveness assessment process to be of value, it would be important that the chosen assessment process could be validated against the actual historical performance of the relevant national agriculture sector. It was decided that for the purposes of validation, an appropriate measure was the real gross value of agricultural production of the nation in question, indexed to a common base year for all nations included in the trial. The rationale for selecting this statistic was that if a nation is experiencing growth in the real value of agricultural production at a faster rate than other nations, then the agriculture sector of that nation must be relatively more competitive.

Two major categories of factors were identified (national and agricultural), and for both these, six different sub-factors were identified, and time-series statistical indicators collated for each of these (see Table 9). The factors and indicators used in the trial index were selected based on the advice of a panel of agricultural economists. In a number of instances, proxy indicators had to be used due to a lack of accessible quantitative statistical data. In other cases, a lack of comprehensive time-series data limited the usefulness of some of the identified indicators.

A decision was taken to focus to the greatest extent possible on higher-level, outcome oriented indicators, rather than more detailed indicators that are essentially inputs to a ‘system’, but do not necessarily assist in identifying how that system is performing. As an example, a focus on a higher level indicator such as national GDP growth rates provides a better perspective of the overall performance of a national economy than does an indicator such as the unemployment rate or levels of capital investment.
Table 9: Factors and indicators for the agricultural competitiveness index

<table>
<thead>
<tr>
<th>Factors</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>National economy</td>
<td>Rate of domestic economic growth</td>
</tr>
<tr>
<td></td>
<td>Real effective exchange rates</td>
</tr>
<tr>
<td></td>
<td>Regulatory environment</td>
</tr>
<tr>
<td></td>
<td>National governance standards</td>
</tr>
<tr>
<td></td>
<td>Shipping connectivity</td>
</tr>
<tr>
<td></td>
<td>Quality of port infrastructure</td>
</tr>
<tr>
<td>Agricultural inputs</td>
<td>Access to capital</td>
</tr>
<tr>
<td></td>
<td>Input efficiency</td>
</tr>
<tr>
<td></td>
<td>Quality of natural resources</td>
</tr>
<tr>
<td></td>
<td>Technology adoption</td>
</tr>
<tr>
<td></td>
<td>Research and development investment</td>
</tr>
<tr>
<td></td>
<td>Marketing efficiency</td>
</tr>
</tbody>
</table>

Data for each indicator was compiled and assessed for seven national agricultural sectors for the period from 1960 to 2013, or for the period over which comparable national data was available. The seven national agriculture sectors selected for inclusion in the comparison were Australia, New Zealand, the USA, Canada, Brazil, Ukraine and South Africa.

Explanations of the factors, indicators, nations, commodity groups, data sources and data modelling involved in the competitiveness assessment process are provided in Appendix 1, along with the results arising from the validation of the chosen indices and composite index with the index value of real gross value of agricultural production (RGVAP) calculated using a five-year rolling average to remove some seasonal volatility. A summary of the relationship between each of the chosen indicators, and the index of RGVAP is provided in Table 10.

The scores for all twelve indicators were combined into a single index, with each of the indicators given an equal weighting. The resulting composite index was compared with the index of RGVAP, firstly for all nations combined, and then separately for developed and developing nations. Plots of the results of this comparison are also shown in Figures 3, 4 and 5.

The results displayed in Table 10, Appendix 1 and the following graphs highlight the limitations associated with the use of specific indicators, or a combination of those, to assess the competitiveness of a national agricultural sector. None of the national indicators selected for inclusion in the analysis were strongly or consistently correlated with the index value of RGVAP for each nation, and even a factor such as exchange rates (for either developed or developing nations), which many would consider a key factor in agricultural competitiveness, did not show a consistent relationship with the index of real national agricultural output.
### Table 10 Correlation coefficient between selected indicator and index of RGVAP.

<table>
<thead>
<tr>
<th>Nation</th>
<th>National economy</th>
<th>Agricultural inputs</th>
<th>Unweighted composite index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP growth</td>
<td>Exchange rate</td>
<td>Regulation</td>
</tr>
<tr>
<td>Australia</td>
<td>-0.06</td>
<td>-0.44</td>
<td>-0.03</td>
</tr>
<tr>
<td>Canada</td>
<td>0.04</td>
<td>-0.11</td>
<td>-0.94</td>
</tr>
<tr>
<td>USA</td>
<td>-0.24</td>
<td>-0.45</td>
<td>-0.34</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.20</td>
<td>-0.27</td>
<td>-0.02</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.12</td>
<td>0.16</td>
<td>-0.57</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-0.41</td>
<td>-0.30</td>
<td>-0.64</td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.04</td>
<td>-0.04</td>
<td>-0.74</td>
</tr>
</tbody>
</table>

* RGVAP was calculated based on a five year rolling average to reduce annual volatility.
For the specific agricultural inputs included in the analysis, the indicators for Input Efficiency and Natural Resources had the most consistent correlation with the index of national RGVAP, although a challenge associated with both these is to determine whether the correlation observed has arisen because these factors cause growth in RGVAP, or whether growth in RGVAP has had the effect of changing these factors. It could be argued, for example, that the correlation between the index of national RGVAP and the proxy indicator used for the quality of natural resources (cereal yields) arises because in a year of good seasonal conditions, yields will increase and the extra volumes of grain harvested will result in an increase in the RGVAP. This does not mean, however, that there has been an increase in the underlying quality of the natural resource base.

The observed relationship between the index of national RGVAP and lagged public agricultural R&D investment intensity in developed nations is also contrary to what most would anticipate should be the relationship. The negative correlation most likely arises due to the fact that the value of agricultural output has been growing for each of these nations over the last decade due to strong global demand, despite declining rates of productivity growth, while public sector agricultural R&D investment has been static, or declining in real terms, and certainly in investment intensity terms. Consequently, for the available data series a negative correlation is generally apparent between R&D investment intensity and the index value of national RGVAP, but few would argue that this is a causative effect and that the way to further increase RGVAP is to actually reduce R&D investment intensity.

Most detailed economic analysis of the role that R&D investment plays in the growth in agricultural output and hence competitiveness over the longer term (see Khan, 2014, for example) concludes there is a significant positive correlation, and the relationship observed here may be a factor of the limited comparable national data sets that are available, and hence the short lag time (fifteen years) used in this analysis.

The final column of Table 10 shows the correlation between an unweighted composite index made up of all twelve indicators included in the analysis, and the index of national RGVAP. It highlights that, even in combination, the indicators selected for inclusion in the analysis do not display a consistent or strong correlation with RGVAP. This is further highlighted in Figures 3, 4 and 5 below, which show plots of the relationship between the aggregated index of competitiveness and RGVAP for each of the nations included in the analysis, and then separately for developed and developing nations.

![Figure 3. Comparison of aggregated competitiveness index scores and index of RGVAP.](image-url)
Further analysis is detailed in Appendix 1, which involved the use of statistical methods to attempt to develop a weighted composite index that might exhibit a closer correlation with national agricultural output and hence competitiveness. While the use of multiple linear regression did result in the creation of a composite index that displayed a closer correlation with the index of national RGVAP, the results need to be treated with some caution. Many of the indicators included in the weighted index as a consequence of the regression analysis do not display any strong correlation with RGVAP, and the signs of the resulting calibration equation coefficients are often the reverse of what would be anticipated.

It is highly probably that, were this equation to be applied to another independent group of nations, the observed correlation between the weighted index and the index of national RGVAP would be much lower. This does not provide great confidence about the usefulness of such an index to make decisions about changes in competitiveness, and associated agricultural policy changes.

Even leaving that issue aside, the usefulness of any of the composite indices developed (either weighted or unweighted) from a policymakers perspective is highly questionable. Many of the factors included in the analysis (for example exchange rates) vary through time as a consequence of factors not related to the agriculture sector. Most of the factors operate over different timeframes, ranging
from almost immediate (in the case of currency exchange rates) to very long term (twenty to forty years in the case of R&D investment), therefore making considered decisions on policy priorities is quite difficult. It also seems highly likely that the effect of several factors in combination (for example low exchange rates and improved infrastructure) might have a more significant impact on competitiveness than single factors in isolation.

A further important issue that emerges from this analysis relates to the purpose for which any proposed agricultural competitiveness indicator is intended to be used. Broadly speaking, the main uses for such an indicator might be (a) to assess the current competitiveness of an agricultural sector, or (b) to assist policy development aiming to improve competitiveness, or (c) to assess the future development and growth potential of an agricultural sector. Intuitively, the factors that might be suitable for inclusion in an indicator would be different, depending on which of these uses was of primary importance. Indicators suitable for assessing the current competitiveness of an agriculture sector might include ‘backward looking’ indicators such as changes in export market share, revealed comparative advantage, past productivity growth and cost of production indicators. Indicators that might be of use for policymakers seeking to improve competitiveness might include measures of the quality of human and natural resources, farm and agriculture sector financial performance, and measures of rates of adoption of innovations. Indicators of use in assessing future growth potential might include measures of the availability of underutilised natural resources, and measures of investment rates in agricultural research and development. Taking the above into consideration, it becomes apparent that it is highly unlikely a single agricultural competitiveness indicator would be of any real value.

This becomes even more apparent with the realisation that in many cases, the availability of suitable data is extremely limited, or non-existent. In a number of cases, the lack of availability of relevant statistics necessitates the use of proxy or high-level indicators, but it is sometimes unclear whether changes in that indicator are a cause of changes in RGVAP, or the effect of changes in RGVAP.

It might be argued that this is a consequence of the use of inappropriate indicators, however the research has highlighted that robust indicators are often not available at the agriculture sector level, even for developed nations. Even in situations where the factors included in a composite competitiveness indicator are relevant, there is also the potential for attention to be focused on why the composite indicator has changed, rather than on the policy issues that might enhance the competitiveness of the national agricultural sector.

Taking all these observations and the results of the preceding analysis into account, a conclusion is that, rather than developing a composite index, a preferred alternative approach that may achieve similar outcomes may be to create a ‘dashboard’ of some key indicators, and to utilise these as an indicator of factors that might improve agricultural competitiveness. The following section of this research report further develops this concept.
A national agricultural competitiveness ‘dashboard’

As established in the previous section, there is no compelling evidence available that a single index, however constituted, can provide a definitive indication of the relative competitiveness of a national agricultural sector. The factors that contribute to national agricultural competitiveness do not appear to be constant across nations, seemingly involve unpredictable interactions, and are often inadequately quantified by available statistics. Given this, it would be misleading and unproductive to proceed with the development of a composite index, especially given that media and policymakers could be expected to simplistically focus on that single figure, without considering any of the underlying factors contributing to it, and without considering the extent to which it provided a true picture of the changing competitiveness of a national agricultural sector. There are also significant questions about the extent to which policymakers would be likely to take an indicator into consideration in making policy decisions, given the lack of strong evidence of the relevance of that indicator.

An alternative approach that may have greater potential is a collection of key indicators that enables comparisons to be made of some of the high-level factors that are well-recognised as being important contributors to the overall long-term competitiveness of a national agricultural sector. This approach can be likened to the dashboard of a car, which provides the driver with information about a number of different systems that all contribute to the performance of the vehicle.

The challenge in such an approach for a sector such as agriculture is that, as already noted, the availability of consistent and comparable data is a limitation. Even agricultural data that is routinely collected by international agencies such as the OECD and the FAO has some well-recognised limitations, as has been noted earlier in this research. Noting that limitation, the preference is obviously for data that is consistently compiled, and ideally is available over an extended timeframe.

Detailed below are four widely available and relevant indicators which provide a potential ‘dashboard’ for researchers and policymakers to reference as part of their consideration of the relative competitiveness of national agriculture sectors. In each instance, data were collated for each of the seven national agricultural sectors previously identified.

In order to further consider the usefulness of this approach, a case study of a comparison between the agriculture sectors of the USA and Australia using this dashboard approach has been prepared.

Dashboard indicator 1: Total Factor Productivity

Total factor productivity (TFP) is estimated by comparing units of output with the units of inputs used to produce those outputs. If total factor productivity is increasing over time, then outputs are being produced more efficiently. The statistic is usually expressed as an index, to better enable comparisons between different sectors or entities. In farming systems, the calculation of TFP growth rates is made more complex due to the range of outputs and the range of inputs used in production systems, and the fact that these can be used in differing combinations.

Trends in the index of agricultural TFP for each of the seven national agricultural sectors included in this research are shown in Figure 6 below. The data were sourced from some earlier analysis conducted by researchers at the US Department of Agriculture (Fuglie et al 2012), which highlighted some inconsistencies in the way calculations of national agriculture TFP are carried out. The research by Fuglie, some related research by ABARES, and the data compiled by Fuglie as part of that research provide a good basis for compiling this statistic on a consistent national basis.
A number of points emerge from this comparison. The strong performance of New Zealand over the period from 2000 to 2006 was in part due to the conversion of areas of land that were previously under forestry projects to dairy farms, as a consequence of low timber product prices and escalating dairy prices. The performance of both Brazil and South Africa was associated with the modernisation of agriculture sectors in both those nations, which assisted farmers in those nations to ‘catch up’ with the productivity performance of more developed nations. The poor performance of Australia was in part related to a sequence of droughts in major cropping regions which commenced in 2003 and extended through until 2010.

Those qualifications noted, the graph indicates that New Zealand, Brazil and South Africa have all experienced relatively strong productivity growth over the past decade, which has likely contributed to enhanced competitiveness, all other things being equal. On the other hand, the poor productivity performance of the Australian agricultural sector post 1997 is of major concern, as it is a very clear indication that the national agricultural sector is losing its competitiveness, relative to the other nations included in the analysis.

**Dashboard Indicator 2: Agricultural Revealed Comparative Advantage**

The concept of revealed comparative advantage was first espoused in 1965 (Balassa, 1965) and since then has been widely used as a measure of a nation’s relative ability to successfully produce and export goods in comparison with its trading partners. Essentially, the measure uses historical patterns of trade to infer relative competitiveness, rather than attempting to identify and quantify all the various factors that may be contributing to that relative competitiveness.

Agricultural Revealed Comparative Advantage (ARCA) is included as a measure of the relative comparative advantage on one nations’ agriculture sector, compared to another nations or the world in aggregate. A nation that has a higher ARCA should be relatively more successful in exporting agricultural products than a nation with a lower ARCA, noting however that the presence of agricultural trade barriers may have a distortionary effect on a nation’s ARCA, and hence may not be a true indicator of the relative competitiveness of a national agricultural sector.
Figure 7 below provides a plot of changes in the ARCA over time for the seven nations included in this research. The data used to calculate the ARCA ratio was sourced from the World Trade Organisation (national trade data) and from the UN Comtrade database (agricultural trade data).

Figure 7: Agricultural Revealed Comparative Advantage.
(Source: AFI analysis, WTO, UN Comtrade)

The graph indicates that both New Zealand and Brazil have experienced improving ARCA indices, indicating that their agricultural sectors have been becoming more competitive, especially since 2000. The Ukraine has also experienced increases in its ARCA over recent years. In contrast, Australia has experienced a declining ARCA since around 2004, indicating that the agriculture sector has been becoming relatively less internationally competitive over that period.

These results highlight that the ARCA is a useful indicator of changes in relative competitiveness, but it does not provide an indication of why relative competitiveness has changed. Caution should also be exercised when referencing the measure in isolation. ARCA movement is partially determined by non-agriculture export volumes. An improving ARCA could be the result of growth in agricultural exports relative to other categories of national exports, but it could also be the result of agricultural exports declining by less than other categories of exports.

Large bilateral trade flows within the agriculture sector can further distort the ARCA. Trade agreements, supply chain development and intra-industry specialisation tend to increase both imports and exports. A growth in agricultural exports may be accompanied by higher growth in agricultural imports, thus lifting the gross export based ARCA while agricultural net exports decrease.

In Australia’s case, it is probable that the decline in ARCA since 2004 is most likely a consequence of the boom in mineral exports since that time (which reduced the relative national importance of agricultural exports), which also resulted in a relative strengthening of the Australian dollar exchange rate, and increases in the cost of labour in the domestic economy. Both of these can be assumed to have had a negative impact on the relative competitiveness of the Australian agricultural sector, noting that there have been reversals in both these over the past two years.
Dashboard indicator 3: Public agriculture R, D & E investment intensity

Agricultural research and development investment has long been considered to be a critical factor in enabling productivity growth in an agricultural sector. As has been noted, “the world as a whole and individual nations have benefited enormously from productivity growth in agriculture, a substantial amount of which has been enabled by technological change resulting from public and private investments in agricultural R&D.” (Alston 2010). This sentiment was echoed in the findings of a recent Productivity Commission review of agricultural research and development arrangements in Australia, as a consequence of which the Commission concluded “Research and development (R&D) plays an important role in enhancing the productivity and competitiveness of Australia’s agriculture, fisheries and forestry industries.” (Productivity Commission, 2011).

Over recent decades, available statistics have indicated that whereas in the past agricultural R&D investment was almost entirely confined to the public sector, there has been significant growth in R&D investment by the private sector. This has occurred as a consequence of opportunities created by public agricultural R&D investment in areas such as biochemistry and plant and animal genetics, which private sector organisations have been able to further develop and commercialise. Unfortunately, with the exception of a number of limited cases, robust statistics on national private sector agricultural R&D investment levels are not available, and hence the focus on public sector investment levels.

The correlation between public R&D investment and agricultural productivity has proven difficult to quantify, despite multiple examples of farmers adopting technology derived from successful R&D investment. Myriad issues including variable R&D investment-return timelags, international knowledge transfer, variation of positioning on or behind the technological frontiers, specialisation of agricultural sectors not to mention variation of R&D and efficacy between countries make a mathematical relationship between R&D and productivity almost impossible to derive.

It could be argued that, as a consequence of the lack of robust and quantified relationship between R&D investment and productivity growth, it is preferable to only include the productivity growth indicator in consideration of national agricultural competitiveness. However, given that productivity growth is understood to have such an extended lag time subsequent to R&D investment, it is appropriate to also consider R&D investment levels as a forward indicator of likely future productivity performance.

The estimated rates of return associated with R&D investment continue to be relatively high (Alston, 2010), which provides confidence that despite the uncertainty of the empirical relationship between R&D investment and agricultural productivity growth, R&D investment remains a key factor contributing to the long term competitiveness of a national agricultural sector.

Figure 8 below provides a comparison of public R&D investment intensity levels (public R&D investment as a percentage of the gross value of agricultural production) for each of the seven nations included in this analysis.
Figure 8: National public agricultural R&D expenditure as a percent of GVAP.

(source: OECD, AFI analysis)

The graph highlights that public sector agricultural R&D investment intensity has been declining in virtually all the nations included in the comparison, with the possible exception of the USA. The marked apparent declines observed in 2007-08 are largely due to the significant increases in the gross value of agricultural production associated with the spike in agricultural commodity prices over that period, and not due to a sudden reduction in R&D expenditure.

It is noteworthy that both Canada and to a lesser extent Australia have relatively higher levels of public investment in agricultural R&D than either the USA or New Zealand, although the extent of decline in investment intensity in both Australia and Canada over the past decade has been significantly greater. The decline in R&D investment intensity in Brazil and South Africa over recent years is also more a factor of the growth in the value of agricultural output in those nations over the period, rather than an absolute reduction in R&D investment.

With the possible exception of the USA and New Zealand, the observed reductions in public agricultural R&D investment intensity over the past two decades suggest that a significant improvement in agricultural productivity in these nations is unlikely over the next decade, notwithstanding the uncertainty in time lags associated with R&D investment.

Dashboard indicator 4: OECD Producer support estimate

Globally, the agriculture sectors of national economies have traditionally been subject to a wide range of government regulations and support measures, aimed broadly at regulating agricultural markets, maintaining food security and reducing the risks faced by farm businesses. While these measures may provide benefits to individual farmers, it is generally acknowledged that the maintenance of these regulations and support measures for an extended period reduces the flexibility of businesses in the agricultural sector, distorts market signals, and has a dampening effect on efficiency and productivity growth. Over time, this has rendered national agricultural sectors uncompetitive, especially when subject to competition from low-cost agricultural exporting nations.

The OECD has for some considerable time compiled annual statistics on the extent of government support measures provided to national agricultural sectors. The methodology developed by the OECD combines the value of trade restrictions, government subsidy programs and indirect payments to farmers (through tax concessions etc.) into a single value, termed the Producer Support Estimate (PSE). The PSE is expressed as the estimated value of government support measures as a percentage
of average annual farm receipts. Figure 9 displays the OECD time series of Producer Support Estimates for the national agricultural sectors of the seven nations included in this analysis.

Figure 9: OECD Producer Support estimates as a percentage of gross farm receipts.

The graph shows that generally, governments in each of these nations have been reducing the effective level of taxpayer subsidies afforded to the agricultural sector. This is particularly the case for the agriculture sectors of New Zealand and Australia, which have the lowest levels of effective government subsidy of any national agriculture sectors in the OECD. Government subsidy levels for the agriculture sectors of Canada and the USA have also declined over the last decade, with part of this decline due to changes in government programs, and part being due to higher agricultural commodity prices over the period, which has meant some price and income support measures have not been triggered.

Considered in isolation, the more regulated and subsidised agricultural sectors of Canada and the USA would be expected to be less competitive in newly emerging markets. The complexity of factors contributing to agricultural competitiveness, and the diversity of different ways governments extend support to their agriculture sectors (for example via renewable fuel standards that result in consumers subsidising ethanol refiners to purchase large volumes of grain) mean that the existence of government support programs does not automatically mean a national agriculture sector is uncompetitive.

An agricultural competitiveness dashboard case study

In order to further consider the usefulness of the dashboard approach to comparisons of agricultural competitiveness, a case-study analysis was carried out involving a comparison between the agriculture sectors of the USA and Australia.

Competitiveness is a relative concept, and the compilation of national indicators for a single nation in isolation reveals little about the relative competitiveness of that agriculture sector compared to other national agriculture sectors. The use of standard international ‘averages’ for each of the relevant indicators would provide a useful benchmark, but unfortunately this information is not available. The alternative approach adopted here has been to use USA data as a relevant benchmark, given both the scale of the US agriculture sector and the availability of robust national data.

The following graphs compare the agriculture sectors of the two nations, utilising the four key indicators detailed in the preceding section, as well as providing a graph of the index values of the RGVAP for both nations.
The graph of trends in the real value of agricultural production shows that both agriculture sectors have only achieved relatively modest rates of real growth in value over the past two decades, although there is some evidence emerging that the growth rate of the agriculture sector of the USA has accelerated since around the year 2000, coinciding with the emergence of China as a major net importer of products such as corn and soybeans (both exported by the US), and the development of stronger renewable fuel policies which increased domestic demand for corn in the USA.

Farmers in the USA have been able to respond to this increased demand (and associated higher commodity prices) by increasing output. The difference in growth rates over the past decade is evidenced by the fact that the average annual growth in the real farm gate value of Australian agriculture between 1996 and 2013 was 0.7% per annum, whereas the average growth rate in the US over the same period was 1.5% per annum.
In considering why the US has been able to achieve higher real growth in agricultural output, given that both the USA and Australia have static or declining availability of arable land and irrigation water, the total factor productivity dashboard indicator provides important information. The graph shows that farmers in the US and Australia were able to achieve relatively similar rates of productivity growth over the period from 1960 to the mid-1990s, but since that time overall productivity growth in Australian agriculture has largely stalled, while productivity growth in the US agriculture sector has been maintained at its previous rate. This difference is quite significant, as it has meant that US farmers have been able to increase the volume of their output in response to higher global commodity prices, which Australian farmers have not been able to do.

The millennium drought in Australia which extended from 2003 to 2009 and resulted in a marked reduction in grain production is likely to have had a negative impact on the measured productivity performance of Australian farms, but the changed trajectory of productivity growth in Australia was in evidence prior to that time, and does not appear to have recovered subsequently.

Factors that are likely to have contributed to the continuing growth in productivity in US agriculture include the widespread adoption of genetically modified crop varieties, and the higher levels of intensification of US agriculture relative to Australia, in particular in the dairy, irrigated horticulture, pork and poultry sectors. There are greater opportunities for more intensive use and refinement of inputs in more intensive production systems than there are in extensive and rain fed systems.

The productivity performance of US agriculture seems to contradict the belief that investment in R&D is linked to productivity performance, in light of the fact that public investment in agricultural R&D is lower in the US than in Australia, when expressed on an investment intensity basis. However, the R&D investment intensity graph provides only part of the story, and is to some extent distorted by changed in gross value of agricultural output rather than R&D investment levels, as Figure 11 shows. The US has maintained annual growth in absolute public R&D investment levels over the past two decades, while in Australia total public agricultural R&D investment has stagnated.

Two other factors are important to consider in relation to rates of agricultural R&D investment. The first is that a nation with a relatively large agricultural sector, like the US, is likely to be able to capture some benefits of scale in its R&D investments, and the second is that there is also a higher level of private sector investment in agricultural R&D in the US than in Australia, in part related to the fact that genetically modified crops are more widely adopted and not regulated as they are in some parts of Australia. Private sector agricultural R&D investment in the US is estimated to be approximately equal to public sector R&D investment, suggesting that overall agricultural R&D investment intensity in the US is likely to be higher than in Australia.
Another factor in the divergence in the growth rates of the real value of agricultural production between Australia and the USA is highlighted by the graph detailing the Realised Comparative Advantage of the agriculture sectors. The Australian agriculture sector has traditionally exhibited a higher Revealed Comparative Advantage than the US agriculture sector, based on Australia’s much higher reliance on export markets. On average, approximately sixty percent of the volume of Australian agricultural production is exported, while for the US agriculture sector, exports markets account for approximately twenty percent of production.

However, over the period from 2004 to 2010, the Revealed Comparative Advantage of Australian agriculture declined significantly, due to a number of factors. These included that growth in mining exports from Australia reduced the relative importance of agricultural exports, droughts reduced total agricultural output, and the relatively high value of the Australian dollar reduced the competitiveness of Australian agricultural exports in global markets. There has been some recovery in Australia’s Realised Competitive Advantage due to increases in beef and grain exports over recent years. This measure is all the more critical for farmers in Australia, who are estimated to be approximately 60% dependent on export markets, compared to just 20% export dependency of American farmers.

The Revealed Comparative Advantage indicator is a lagging indicator that highlights past changes in agricultural exports relative to total exports and could therefore be considered to be of limited value for policymakers. However, it does provide a clear picture of changes in the relative importance of national agricultural exports, alerting policymakers to the possible need to consider ways to respond to significant changes.

The fourth indicator included in the above dashboard comparison is the OECD’s PSE statistic, indicating the level of government support being provided to the respective agriculture sectors. Australian farmers have traditionally considered US farmers to be heavily subsidised and therefore uncompetitive, however progressive changes in US farm programs over recent iterations of the US Farm Bill have reduced the reliance of US farmers on direct payments and subsidy programs, and increased the focus on more commercially-oriented insurance programs.

These changes have not only reduced the effective level of subsidy provided to US farmers, but have also removed many of the constraints that in the past may have reduced the market-responsiveness of US agriculture. This policy change is perhaps part of the reason that the US agricultural sector has been able to maintain rates of productivity growth, and higher real growth rates that Australian agriculture over the past decade.
It is also noteworthy that US farmers operate in a domestic market of some 320 million persons with relatively high (in global terms) per capita income, compared to Australian farmers who operate in a domestic market of some 23 million persons. While more open global agricultural trade policies mean that a nation’s farmers can no longer consider their domestic markets to be their ‘own’, they do have significant competitive advantages in their home markets in terms of generally lower transport and logistic costs, and a better ability to deliver fresh produce to domestic consumers.

Discussion and conclusions

The preceding discussion about the findings arising from the ‘dashboard’ approach highlight that while this approach to analysing agricultural competitiveness has significant advantages over the single composite index approach, it still does not present a complete explanation of why one nation’s agriculture sector might be becoming more competitive and expanding, while another nation’s may not.

As the example highlights, there are a wide range of different factors, and interactions between these factors, that contribute to the competitiveness of a national agricultural sector. These cover the full range from natural resource endowments to the types of commodities produced, the nature of the markets those commodities are destined for, the domestic and international governance and regulatory environment, and the transport and logistics environment in both domestic and international markets.

It is also evident from the research and analysis reported here that the combinations of factors that are important differ for individual nations, and that there are risks associated with oversimplifying these by reducing analysis to a small number of key indicators.

Having said that, the five indicators incorporated into the ‘dashboard’ provide some very useful insights into the differences between national agricultural sectors, and are useful as a starting point for further consideration about why one national agricultural sector may be growing more rapidly than another.
Further development of an agricultural competitiveness assessment process

The results arising from the trial of the development of a composite national agricultural competitiveness indicator did not give any confidence that the use of the composite indicator would provide any real benefit in terms of assessing agricultural competitiveness, or in making decisions about the impact of specific policy initiatives on the competitiveness of a national agricultural sector.

The quality of national agricultural statistics notwithstanding, the factors that contribute to national agricultural competitiveness are obviously diverse, complex, somewhat unpredictable, and often unquantified or poorly quantified. As such, simplistic or formulaic approaches to the assessment of agricultural competitiveness are likely to produce misleading outcomes that would be of limited value to either policymakers or industry participants.

The dashboard approach, however, whereby an assessment of national agricultural competitiveness is based on a number of widely used and well-developed statistical indicators, may provide a more robust assessment of factors considered to be of critical importance to national agricultural competitiveness.

That said, the case-study example detailed in this research has highlighted that an increased understanding of relative agricultural competitiveness will only arise if the dashboard indicators trigger further analysis into some of the underlying differences between national agricultural sectors, rather than are accepted as a complete explanation.

In either case, the lack of availability of relevant, long-term, reliable and internationally comparable agricultural statistical data is a major limitation to the development of sector-specific competitiveness indicators for national agricultural sectors.

There appears to be some value in further development of the dashboard approach, given the challenges experienced by agricultural sectors globally in ensuring that governments allocate sufficient resources and policy attention to national agricultural sectors, and given the widely recognised need to increase global agricultural output in response to population growth and changing dietary preferences in developing nations. However, it is apparent that a wider range of indicators may need to be considered, and that the critical indicators that are relevant will vary for different nations.

An important first step in further developing this approach will be to try and improve the quality and international comparability of agricultural statistics. Groups such as the FAO, the World Bank, the World Trade Organisation, the OECD and the United Nations all have a common interest in improving global agricultural statistics, and most of these have initiatives underway to try and achieve this aim.

To the extent that it is feasible, the Australian Government should provide support for these initiatives. To a significant degree, however, the quality of agricultural statistics compiled by these organisations is dependent on the quality of agricultural statistics provided to them by national governments.

At the national level, the quality of Australian agricultural statistics has been diminishing for some time. (Potard and Keogh, 2013). Clear evidence of this is provided by the discontinuation of agricultural data series that were previously compiled by the Australian Bureau of Statistics, and the incomplete coverage that is currently available of agricultural sub-sectors such as horticulture and intensive livestock. These shortcomings are further reinforced by the errors observed in the Australian data provided to the OECD which is used in that organisation’s international comparisons of agricultural support measures. If there are similar errors in other national agricultural data held by that organisation, then this would severely limit the potential use of the data to better understand national agricultural competitiveness.
The Australian data detailing the amount of public agricultural R&D expenditure appears to grossly underestimate annual national public sector agricultural R&D expenditure, even leaving aside the uncertainty about how R&D levies paid by Australian farmers should be treated. Unless these and related shortcomings are addressed, there is little prospect that meaningful understanding of the factors important to agricultural competitiveness will be achieved.

This reinforces the desirability of the dashboard approach which does not focus narrowly on a single index or number, and which utilises higher-level comprehensive data that is less likely to be incorrect, or to be highly volatile. However, even that approach should be used as the basis for further investigation, rather than being considered to present a complete picture.

Within Australia, there are a range of different stakeholders that have an interest in further progressing an understanding of the factors that contribute to agricultural competitiveness. These include:

- the owners of farm businesses, the profitability of which depend upon the extent to which these businesses remain competitive,
- the Australian and state governments, which provide a range of different services to the farm and wider agriculture sector, including agricultural research and development funding, biosecurity policy and services, and which have an interest in the economic impact of the agricultural sector on regional and national economies,
- the agribusiness sector which services farmers,
- agricultural research providers including universities and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which is the largest single provider of agricultural R&D services nationally,
- the fifteen rural research and development corporations, most of which collect farmer levies and matching contributions from government, and utilise those funds to procure agricultural R&D activities and to extend the results of that research to farmers, and,
- a range of government economic and policy organisations which analyse economic and policy issues and provide advice about the impact of current and future policies on the agricultural sector.

Some of these, such as the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and various university agricultural economic faculties have had some engagement in research into national agricultural competitiveness. In addition, the Australian Government is in the process of finalising an agricultural competitiveness white paper, which will also presumably be addressing issues associated with enhancing agricultural competitiveness. Others, including many of the rural research and development corporations, need to improve their understanding of, and ability to communicate to stakeholders about, the impact of their activities on the competitiveness of Australian agriculture.

The findings of the research reported should be of interest to all these stakeholders, as should the potential to utilise a tool such as the agricultural competitiveness dashboard in order to assist in decision-making about future policies and activities aimed at improving Australian agricultural competitiveness.

Internationally, there appears to be merit in encouraging relevant agencies in nations or groupings such as the USA, Canada, New Zealand, the EU and some of the emerging developing national agricultural exporters to become involved in further developing and refining comparisons of international agricultural competitiveness, using an approach such as has been outlined here.

Within Australia, given the cross-commodity nature of the issue, the Council of Rural Research and Development Corporations and ABARES are relevant groups and organisations that should be encouraged to further develop the concept and use it to better understand the factors contributing to national agricultural competitiveness.
Appendix 1. Trial national agricultural competitiveness index

The trial agricultural competitiveness assessment index involved the collation of statistics relevant to twelve separate factors considered likely to impact on agricultural competitiveness. These are detailed below.

**Indicators for national economy factors**

The performance of the national economy was identified as a major factor to be considered when assessing the competitiveness of a national agricultural sector. The relative performance of a national economy provides a general indication of the social, natural and business environment that farm businesses operate within. Economy-wide factors have an influence on the strength of domestic demand for agricultural products (modified to some degree by export demand and exposure) and also influence the operating environment of businesses involved in providing goods and services for the farm sector, or involved in the post-farm supply chain. The extent to which governments factor agriculture into their decision-making on policy issues varies enormously by nations. The ability of those involved in the farm sector to have a direct influence on these economy-wide factors is also quite limited, although this varies by nation. There were six different indicators identified for measuring the performance of a national economy.

**Rate of growth of Gross Domestic Product.** Domestic economic growth as measured by the annual change in gross domestic product (GDP) provides an indication of how well an economy is functioning. Economies that are experiencing high rates of GDP growth are likely to be more competitive generally, which in turn is also likely to mean that general economy-wide factors of importance to agricultural competitiveness (for example transport and telecommunications) should also be changing in ways that assist the relative competitiveness of the agricultural sector. This may not be true over very short timeframes (for example growth in other sectors of a national economy may result in agriculture being outcompeted for available labour) but in the medium to longer term the advantages for agriculture would generally seem likely to outweigh the disadvantages.

**Real effective exchange rate.** The real effective exchange rate provides an indicative value of a nation’s currency against a weighted average of trade partner currencies. Importantly, the real effective exchange rate is adjusted for domestic inflation and as such, provides a more accurate assessment of the purchasing power of a nation’s currency, relative to that of other currencies. A nation’s real effective exchange rate is usually expressed as an index number, with a relatively high index number indicating that a currency is overvalued (and hence renders export sectors such as agriculture less competitive in both domestic and international markets) and a low index number indicating the opposite.

National Real Effective Exchange Rates (REER), are calculated and published annually by the World Bank. The method of calculation of a nation’s REER is as follows:

\[
\text{REER} = \sum (\frac{\text{LCU}}{\text{FCUi}}) \times \left(\frac{\text{CPIi}}{\text{CPI}}\right)
\]

where:
- LCU is local currency unit
- FCUi is a unit of foreign currency of country i
- CPIi (or GDP deflator) of foreign country i
- CPI (or GDP deflator) of local country
**National regulatory environment.** An assessment of the regulatory environment provides an indication of the ease of doing business in an economy. If the regulatory environment is more conducive to starting and operating a business then this is an indication that businesses face less red-tape and regulations that impede their competitiveness.

One available international indicator for this factor is the Ease of Doing Business indicator published annually by the World Bank. The data that is used to calculate this indicator annually is obtained from the Ease of Doing Business survey conducted and reported by the World Bank Group each year.

This survey asks senior business executives to rank a nation in terms of ten specific actions that are associated with either starting up or running a business. These are; starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency. The responses on each of these issues are given equal weighting in an overall index, and used to rank nations in terms of their relative ease of doing business.

While not all of the actions included in this index are relevant to a farm business and there is no reference to environmental regulations, for example, it is assumed that this indicator provides a reasonable proxy of the ease of operating a farm business in the relevant nation.

**Governance standards.** The governance standards that are applied within a nation are quite important in terms of decisions that are made by business owners to invest in their businesses, and hence to achieve sustained productivity growth. Poor governance standards mean that business owners may face public sector corruption, and hence be less confident about making long-term investments to increase the productivity of their business. Relatively good governance standards are likely to reduce the potential for abusing entrusted power for private gain, which effectively improves the competitiveness of businesses in sectors such as agriculture.

Data for the governance indicator are obtained from the World Corruption Perception Index which is updated annually by Transparency International. The World Corruption Perception Index prides itself as a measure of the perceived levels of public sector corruption in 175 countries and territories.

**Shipping connectivity.** A measure of shipping connectivity provides an indication of the range of international trade opportunities that exist for exporters operating in specific nations. The more shipping options that are available for trading goods overseas the greater the potential there is for businesses, and in particular businesses in the agricultural sector, to competitively participate in international trade.

The shipping connectivity information used was the Liner Shipping Connectivity Index published by the World Bank. The Liner Shipping Connectivity Index is computed by the United Nations Conference on Trade and Development (UNCTAD) based on five elements of the maritime transport sector of each nation, which are;

1) The number of ships servicing that nation,
2) their container-carrying capacity,
3) the maximum vessel size,
4) the number of services, and
5) the number of companies that deploy container ships in a country's ports.

**Quality of port infrastructure.** The quality of port infrastructure indicator provides a measure of the efficiency of the port infrastructure available to exporting companies in specific nations. This indicator was chosen for inclusion as it provides an indicator of the likely costs (both monetary and time) associated with exporting from or importing goods to a specific nation. Such costs can be particularly important for agricultural commodities, which are commonly exported in an un-processed, low unit-value form. The quality of port infrastructure is also considered to provide an indication of national transport infrastructure more generally.
Data that forms the basis of the Quality of Port Infrastructure index originates from the World Economic Forum's Executive Opinion Survey on the standard of port development. In the case of landlocked nation, the Executive Opinion Survey asks business executives’ to rate how accessible port facilities are for exporters based in that nation.

**Indicators used for agriculture-specific factors**

Indicators of agriculture-specific factors considered likely to contribute to national agricultural competitiveness were identified as the second major group of factors to be assessed when developing an assessment process of the competitiveness of a national agricultural sector.

**Access to capital.** The amount of credit or capital made available by banks to farm businesses within a national economy provides an indication of the growth potential and perceived risks associated with farm businesses in each nation. The indicator chosen to measure this was the amount of bank lending to the agriculture sector expressed as a ratio of the Gross Value Added of the national agriculture sector. The Gross Value Added (GVA) statistic is a measure of the net value of agricultural production (Gross value of output minus the value of production inputs used).

A higher level of bank lending relative to GVA of the agriculture sector indicates that banks perceive that the sector has growth potential, and that risk is adequately managed. Low levels of credit, or a lack of available capital is a strong indication that there are fundamental weaknesses in the operating environment for farm businesses. Consequently, a higher ratio of capital availability within a national agriculture sector, especially over the longer-term, was considered to be a likely indicator that farm businesses are operating in a competitive business environment.

The capital indicator involves collecting and analysing data from a nation’s official statistical agency on bank debt and the OECD on gross value of agricultural production. The calculation method for the capital indicator involves the following:

\[
CI = \frac{D}{GVA}
\]

where:
- CI is capital index
- D is official bank debt for the sector
- GVA is gross value added for the sector

**Agricultural input efficiency.** Calculating input efficiency provides an indication of the efficiency of labour and capital utilisation in a national agriculture sector over time. The more efficient that a national agriculture sector is in generating GVA for each unit of labour and fixed capital used, the more competitive farm businesses in that agriculture sector are likely to be relative to farm businesses in other nations that do not have a similar level of efficiency.

Calculation of the input efficiency indicator involves collecting and analysing data from a nation’s official statistical agency. The ratio was calculated by dividing the value of agricultural GVA by the value of labour and capital inputs (the latter estimated as capital depreciation). The calculation method utilised to estimate the Input Efficiency indicator was as follows:

\[
IE = \frac{GVA}{(K + L)}
\]

where:
- IE is input efficiency
- GVA is gross value added for the sector
- K is depreciation of fixed capital
- L is labour costs
Quality of natural resources. Given that agricultural production requires the utilisation of natural resources such as land and water, and given that the suitability of land and the availability of water and suitable climatic conditions can have a major impact on agricultural production, it was apparent that an indicator of the quality of natural resources should be included in any assessment of national agricultural competitiveness.

There have been a number of different approaches adopted internationally to develop objective assessments of the quality of natural resources available to an agricultural sector. These have involved the use of land capability assessments and classification systems, although the classification systems are necessarily very broad in scale, and do not necessarily account for variations in climate, or the availability of water via irrigation. Such systems are also not easily able to be incorporated into an index or ranking system, for the purposes of assessing competitiveness. It is also difficult to utilise these systems in situations where landuse is expanding, and new areas of land are being utilised.

An alternative approach adopted for the purposes of the research reported here was to utilise average cereal yield as a proxy for the quality of natural resources available to the national agriculture sector. Average national cereal yield is a product of the quality of the land utilised for cropping, the suitability of climatic conditions and seasonal rainfall or irrigation water, and the management skill of farm business operators. Of these, the quality of the natural resources (soil, water and climate) are likely to be the major limiting factors, therefore cereal yields are likely to be a reasonable proxy of natural resource quality.

The advantage of this proxy measure as an indicator of natural resource quality is that the statistic is available for most national agricultural sectors over an extended time series. While subject to annual variation due to seasonal conditions within each nation, this variation is less significant over the longer term, especially at an aggregated national level. This statistic is also likely to be sensitive to changes in landuse – for example if cereal cropping is expanding into more marginal areas, this will be reflected in static or declining national cereal yields.

Data for the natural resources indicator are obtained from the World Bank database, which utilises FAO statistics. The natural resources indicator measures a country’s average yield (volume) per hectare of cereal crops. The data modelling method for the natural resources indicator involves the following:

\[
Y = \frac{V}{Ha}
\]

where:

- \(Y\) = yield volume in metric tonnes
- \(V\) = total cereal produced
- \(Ha\) = total hectare harvested

Technology adoption. The rate of adoption of new innovations and technologies in a national agriculture sector is widely considered to be an important factor in achieving productivity growth, and therefore maintaining or improving national agricultural competitiveness. The rate of technology adoption in a national agricultural sector is also considered to be an important indicator of the effectiveness of the national agricultural innovation system, including agricultural research, development and extension agencies and activities.

There are no readily available indicators published at an internationally-comparable level that provide a reliable indicator of the general rate of technology adoption within national agricultural sectors. There are some very specific indicators, such as the rate of adoption of genetically modified crops or the rate of adoption of minimum tillage cultivation, although even these have limited availability and national coverage.

The approach adopted for the purposes of the research reported here was to use the rate of increase in average livestock and crop yields (per animal or per hectare) as a proxy measure of the rate of technology adoption within a national agricultural sector. While there are factors other than technological change that impact on crop yields and livestock production per head, a sustained
increase in these indicators over time seems likely to be a reasonable indicator of the rate of technology adoption that is occurring within a national agricultural sector.

Data for this indicator was sourced from the FAO statistical database. Data were obtained for average pork, chicken meat, milk, beef and sheepmeat production per head of livestock over the period from 1960 to 2012, and the rate of annual increase for each of these was calculated. Similarly, data for average cereal yields per hectares were obtained over the same timeframe, and average annual increases in yield per annum were calculated. The livestock and crop statistics were then combined for each nation, with an equal weight allocated to each, and an overall national indicator was calculated for each national agricultural sector included in the competitiveness assessment. The technology adoption indicator was calculated as a three-year-moving-average growth rate in a nation’s livestock and crop yield.

**Research and development investment intensity.** The level of investment in agricultural research and development that is occurring within a national agriculture sector was considered likely to be an important indicator of both the current and future rate of productivity growth, and hence the likely future competitiveness of businesses within the sector.

Investments in agricultural research and development can be made by either the public or the private sector. In the case of private sector investment, the emergence of major, multi-national bioscience and agrichemical companies which distribute products and technologies globally makes it difficult to attribute the research and development investment by these organisations on a national basis. Research investment in one nation may lead to products and technologies that are distributed in many different national agricultural sectors. For that reason, the focus in the research reported here was on public sector agricultural research and development investment for each of the nations included in the research. It was considered that this research would be more specifically focused on issues of direct relevance to farm businesses within that nation, and therefore of more direct relevance in enhancing the relative competitiveness of a national agriculture sector.

The amount of public expenditure on agricultural research and development relative to the gross value of agricultural production was chosen as an appropriate indicator for this factor. The higher the level of investment intensity in research and development in the agricultural sector, the more likelihood there is of new innovations being made available for adoption by the businesses involved in that agriculture sector in the future. A relatively higher ratio of investment in agricultural research and development would increase the agricultural sectors competitiveness in the long term.

A particular difficulty in compiling the data associated with this indicator is that Australian statistics are highly questionable. Australia, along with all the other nations included in this research, reports on a wide range of different government support measures for the agriculture sector to the OECD each year. Included in these statistics is government investment in agricultural research and development, both directly by the CSIRO and by state governments, and also indirectly via the matching government contributions to the rural Research and Development Corporations (RDCs). However, an examination of the detail included in the OECD annual report for Australia reveals that matching government contributions for only five of the thirteen RDCs are included in the data for Australia. Consequently, the OECD database records a total of $32 million of government contributions to agricultural R&D via the RDCs in 2013, whereas the Department of Agriculture’s Levy Management Unit reports $203 million and $238 million in government matching contributions for 2012-13 and 2013-14 respectively.

A further difficulty in relation to the Australian data is that there is considerable potential for double counting of actual agricultural R&D expenditure, as R&D expenditure by an RDC that is provided to an organisation like the CSIRO is counted as R&D expenditure by the R&D Corporation, then as income earned by the CSIRO, and then as research expenditure by the CSIRO. For this reason, recent attempts to more accurately identify agricultural R&D investment in Australia have focused on the expenditure of organisations conducting the actual research, rather than the organisations procuring the research.
To overcome some of these uncertainties, a data series compiled by Mullen (Mullen, 2010) which only includes research expenditure by actual research providers (and not by funders) was used for the Australian government agricultural R&D expenditure data. This data was spliced with more recent Australian Bureau of Statistics data (ABS, 2013) to provide a long-term data series (the two series differing by some 8% during the period of overlap between them).

An additional challenge in relation to Australian public investment in agricultural R&D arises from the R&D levy system that operates in Australia, but not in other nations. Australian farmers are required to pay an annual tax, approximately equivalent to 0.5% of their gross value of production, which goes to the relevant rural research and development corporations, to be spent on agricultural R&D. These funds are not sourced from government, and therefore would not normally be included in national statistics detailing government investment in agricultural R&D. However, by analysing R&D expenditure by research providers, no distinction is made between funds sourced from government, and funds sourced from industry via compulsory levies. Therefore, the Australia data included in this analysis includes both government and compulsory industry investment in agricultural R&D in Australia. For nations other than Australia that were included in the comparison, the research and development investment indicator used data from the OECD PSE database (OECD, 2013).

Investment in agricultural R&D is known to have a lagged impact on agricultural productivity, with the lag between investment and innovation adoption considered to be of the order of fifteen to thirty years, depending on the nature of the innovation in question. The difficulty that arose in this analysis was that time-series data of public-sector agricultural R&D investment levels were generally only available from the early 1980s for developed nations, and for a much shorter period for developing nations. To minimise the limitations associated with data availability, a fifteen year lag was assumed for the purposes of the analysis. While a longer lag period was desirable, the data were not available to enable such calculations to be carried out.

Total public expenditure on agricultural research and development over the previous 15 year period prior to a specific year was added together, and expressed as a ratio of the specific year gross value of agricultural production. The ratio of public research and development expenditure to production provides an indication of the research and development investment intensity for that sector.

The data modelling method for the research and development investment indicator involved the following:

\[ RDi = \frac{Erd}{GVAP} \]

where:

\[ Ti = \text{Technology investment} \]
\[ Erd = \sum (t_{14} - t_0 \text{ Public expenditure on agricultural research and development}) \]
\[ GVAP = \text{Gross Value of Agricultural Production} \]

**Marketing efficiency ratio.** The marketing efficiency ratio was constructed to provide an indication of a nation’s competitiveness in supplying agricultural products from the farmgate to major international import markets. The indicator was essentially a measure of the relative difference between the prices a nations farmers receive for their produce at the farmgate, and the prices of those same goods at major international market destinations.

A high marketing efficiency ratio indicates that the prices received by a nation’s farmers are relatively high, in comparison with an international benchmark price. A high marketing efficiency ratio may indicate any or all of a number of things including:

- the quality of the agricultural product from a nation relative to the world average quality for that product is high, and/or
- the supply chain from farm-gate to international market is relatively efficient; and/or
- the market access arrangements for agricultural product from a specific nation may be relatively favourable.
Irrespective of the reason for a relatively higher marketing ratio, the end result will be that products from that national agricultural sector will be more competitive in global agricultural markets.

Data on the marketing efficiency indicator was obtained from the OECD and the FAO. Because different nations have a different mix of commodities in their national agricultural output, (and different commodity supply chains post the farmgate have different steps involved and therefore costs) it was important to identify standard commodities for inclusion in the comparison. For that reason, three standard, largely generic traded agricultural commodities were selected for inclusion in this indicator. These were beef, wheat and dried milk powder.

The marketing efficiency indicator for each nation was calculated by obtaining data on the average unit farmgate values of beef cattle, wheat and (cow) milk. The average farmgate unit values for each product were then divided by the relevant international import price for each product.

The world import price for grain was based on wheat, the world import price for beef was based on semi-processed beef and the world import price for dairy products was based on whole milk powder. The sum of the three ratios was considered to provide an overall indication of a nation’s marketing efficiency for agricultural products. The calculation method for the marketing efficiency indicator involved the following:

\[
M = \frac{Gpp}{Wwip} + \frac{BCpp}{Bwip} + \frac{Dpp}{MPwip}
\]

where:
- \(M\) = overall marketing score
- \(Gpp\) = Grain producer price
- \(Wwip\) = World import price for wheat
- \(BCpp\) = Beef cattle producer price
- \(Bwip\) = World import price for beef
- \(Dpp\) = Dairy producer price
- \(MPwip\) = World import price for whole milk powder.

**Form of indicators utilised**

One question requiring consideration in the construction of a trial overall indicator to assess agricultural competitiveness was whether to use rankings or indexes to construct each individual indicator, and any consolidated national indicator.

Some international competitiveness assessment processes utilise national rankings, and changes in national rankings, as the overall indicator and these are reported as such. Such an approach is suitable for comparisons that involve large numbers of nations, although these also require the availability of comprehensive data for each of the relevant factors for each of those nations. In the case of a comparison between a limited numbers of nations, rankings are much less relevant. For example, if a comparison on a specific factor involves three nations, and one of these has a very high raw score while the other two have much lower raw scores that are essentially similar, then the rankings allocated to these nations (1, 2 or 3) do not provide a good indication of the relative differences between them.

In order to overcome this limitation in a competitiveness comparison only involving a limited number of nations or in a comparison only involving two nations, the use of an index approach appears more suitable. An index provides a better indicator of the relative differences between two nations. An index can also be used in cases where some data is available as a ranking, while other data is expressed as raw scores or in some other form.

For the competitiveness comparison reported here, all the data used for each of the indicators included in the analysis was converted to a standard index form, and the signs (- or +) of the values were adjusted so that in all cases, an increase in an index number corresponds with a change that is
considered positive for the competitiveness of the relevant national agricultural sector. The index scores for each factor were also normalised over a range from 1 to 100, using the following formulae;

- Indexed value \( (x) = 1 + (x - \text{MIN}) \times \left( \frac{99}{\text{MAX} - \text{MIN}} \right) \) – (For indicators presumed to be positively correlated with increased agricultural production), and
- Indexed value \( (x) = 1 + (\text{MAX} - x) \times \left( \frac{99}{\text{MAX} - \text{MIN}} \right) \) – (For indicators presumed to be negatively correlated with increased agricultural production)

### Selection of national agricultural sectors and commodities for comparison.

The seven nations selected for inclusion in this trial comparison of agricultural competitiveness in the index were selected on the basis of the availability of relevant data, and also because they also export similar agricultural commodities to those that are produced and exported in Australia, such as wheat, beef and milk powder. The nations were also chosen on the basis of some being developed nations, while some are developing nations. The nations included in the comparison were Australia, New Zealand, the USA, Canada, Brazil, South Africa and the Ukraine.

### Agricultural competitiveness index validation

An important issue in constructing a competitiveness assessment process is the extent to which any constructed competitiveness indicator predicts results that reflect actual outcomes. It is relatively easy to construct an indicator that appears to incorporate appropriate factors, but this is of little benefit unless the combination of factors included in the index produces results that actually reflect the competitiveness performance of the national agriculture sector in question.

For validation purposes, it was decided that the appropriate independent measure of the performance of a national agriculture sector that should be used to validate the performance of any agricultural competitiveness index was the annual real gross value of agricultural production (RGVAP) of each nation. Positive annual changes in the real (inflation adjusted) value of national agricultural production indicates that the national agriculture output is increasing in real terms, and that the sector is therefore maintaining and most likely improving its competitiveness in both domestic and export markets.

Because factors such as droughts and individual commodity price fluctuations can create sudden short-term changes, the annual gross value of agricultural production for each nation was smoothed for the purposes of validation, by utilising a five year rolling average figure.

### Trial Results

Data were collected for each of the agricultural competitiveness indicators identified previously, which include six ‘National Economy’ indicators and six ‘Agriculture-specific’ indicators for each of the seven nations included in the research. Data for each of these indicators were generally available for the period since the 1960s, however, in the case of several selected indicators such as those associated with access to shipping and ease of doing business, data were only available for the past decade. Similarly, the availability of agriculture sector financial data varied considerably for the included nations, with data for a number of the included nations only being available for a limited period.

The seven nations included in the analysis were Australia (AUS), Canada (CAN), the United States of America (USA), Brazil (BRA), New Zealand (NZ), the Ukraine (UKR) and South Africa (SA).

This section discusses the results for each national agriculture sector competitiveness indicator and the correlations between the indicators and each nations real gross value of agricultural production (RGVAP) respectively.
Indicator 1 – Rate of growth of Gross Domestic Product (GDP)

The first ‘National Economy’ indicator included in the analysis was the Rate of growth of national GDP. The rationale for including this indicator was the belief that national economies that are experiencing high rates of GDP growth are likely to generally be more competitive, and that as a sub-sector of a national economy, the agriculture sector is likely to benefit through factors such as improved infrastructure, increased investment and more efficient services.

The indicator utilised was the annual change in the relevant national economies gross domestic product (GDP), as reported by the World Bank. As noted previously, the results were normalised on a scale of zero to one hundred, over the entire period for which data were available. Figure 12 illustrates the indexed annual results for the Rate of growth of GDP indicator for each nation included in the analysis, for the period from 1990 to 2013.

The graph highlights the extreme volatility experienced in the national economy of the Ukraine over this period, and also that there is a degree of correlation between the national economic growth rates of the developed national economies included in the analysis, although different nations grow at relatively faster or slower rates over different periods.

Overall, over the period from 1990 to 2013, the average rate of growth in annual GDP for the Australian economy was the highest of all the nations included in the comparison (see Table 11). Australia’s GDP (real terms) increased by 103% over the period from 1990 through to 2013 and was also the most stable in terms of annual growth rate (as indicated by the relatively low standard deviation in annual growth rate over the period).

Ukraine’s national rate of annual GDP growth was both the lowest, and the most volatile of all the nations included in the analysis. The prevailing political instability and related lack of investment in infrastructure and governance structures in that nation has made it difficult for the national economy of Ukraine to optimise the use of available human and natural capital. As a consequence, Ukraine’s overall GDP growth was the lowest of any of the compared nations between 1990 and 2013, actually declining by approximately 30% over the period (see Figure 13).
Table 11: Total GDP growth (real terms) and annual GDP growth volatility

<table>
<thead>
<tr>
<th></th>
<th>Total GDP growth 1990-2013</th>
<th>Standard deviation (%) of annual GDP growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>103.27%</td>
<td>1.24%</td>
</tr>
<tr>
<td>Canada</td>
<td>70.32%</td>
<td>1.88%</td>
</tr>
<tr>
<td>USA</td>
<td>76.19%</td>
<td>1.72%</td>
</tr>
<tr>
<td>Brazil</td>
<td>94.94%</td>
<td>2.57%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>88.05%</td>
<td>2.02%</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-29.02%</td>
<td>8.98%</td>
</tr>
<tr>
<td>South Africa</td>
<td>83.41%</td>
<td>2.10%</td>
</tr>
</tbody>
</table>

Figure 13: Index of GDP growth of nations included in the analysis (1990 = 100)

To gain some perspective of the relationship between national GDP growth rates and the rate of growth of national agricultural output, and also to test the assumption of a positive correlation between national GDP growth and growth in national real gross value of agricultural production, correlations were calculated between the two variables for each of the nations included in the analysis.

The resulting correlation coefficients were somewhat inconsistent, and varied between positive and negative with no consistent pattern for either developed or developing nations. When the results were aggregated for all the nations included in the analysis for which consistent data was available, there was a positive correlation between national GDP growth and real gross value of agricultural production growth, although the limited timeframe over which a complete set of data were available (1997 – 2013) diminishes the robustness of this result. In the case of both Australia and New Zealand, the correlation was moderately negative, whereas for the USA the correlation between these two measures was positive.

There are a number of assumptions about the likely relationship between national GDP growth and RGVAP, and why this may vary between nations.

In the case of developing nations, sustained GDP growth will in most cases increase the demand for agricultural products within the domestic market. However, this effect is less likely to be significant in
developed nations which tend to exhibit a lower level of demand elasticity for agricultural products and in particular food products.

Developing nations also tend to experience stronger population growth than developed nations, as health and nutrition standards improve. Population growth provides a boost to GDP and overall domestic demand for agricultural products. Persistent increases in domestic demand for food are assumed to provide positive price incentives for agricultural producers, even in cases where national agricultural sectors are actively involved in export markets. The benefits of population growth for total food demand also arise in developed nations, although these nations tend to have slower rates of population growth.

In developed nations, the correlation between national GDP and RGVAP would be anticipated to be positive over the longer term, for the same reasons that apply in developing nations. However, over the shorter-term, the situation may be reversed, especially in situations like the USA or Australia where agriculture makes up less than 5% of the national economy. For example, a short-term period of rapid economic growth in a national economy would be expected to drive up labour costs, and result in higher currency exchange rates and interest rates. All these would disadvantage the agriculture sector in the short term, even though in the longer term it may result in improved input efficiency and productivity in the sector.

An example of evidence that trends in national GDP may have impacted negatively on national RGVAP over a relatively short time period is the example provided by Spain. Figure 14 shows there has been an apparent inverse relationship between Spain’s GDP and RGVAP post the global financial crisis which started in 2007/08.

![Figure 14: Trends in Spanish GDP and RGVAP.](Source: UN Comtrade database)

In conclusion, there is no strong evidence available from the data used in this analysis that there is a strong correlation between a nation’s GDP and RGVAP growth, however logic suggests that there is merit in including national GDP growth in an index of agricultural competitiveness because of the importance of broader national economic factors on the relative competitiveness of a national farm sector.
Indicator 2 – Real Effective Exchange Rates (REER)

The second indicator included amongst ‘National Economy’ indicators is the nation’s Real Effective Exchange Rate (REER). A nation’s REER is usually expressed as an index number, with a relatively high index number indicating that a currency is overvalued (and hence renders export sectors such as agriculture less competitive in both domestic and international markets) and a low index number indicating the opposite. In the analysis reported here, it has been assumed that an overvalued currency creates a disadvantage for a nation’s agricultural exporters, and hence when expressed as an index value, is a lower index number (on the scale of 0 – 100) that would be the case for a nation with an undervalued currency.

Figure 15 provides a comparison of results for the indexed REER for all the nations included in this research, for the period from 1975 to 2013.

The graph shows that Australia’s currency was relatively undervalued in comparison with competitors up until 2001, and hence Australia ranked close to the top of the graph shown in Figure 6. Since that time, Australia’s currency strengthened relative to the value of the currencies of the other nations included in the analysis, rendering Australian agricultural exporters less competitive, and hence the graph line for Australia trended downwards, and at a faster rate than was the case for other agriculture-exporting nations. As the graph shows, Australia went from being one of the most competitive nations (based on relative currency values) over the period from 1985 – 2001, to become the least competitive nation by 2009, a position which Australia has maintained since that time. The graph shows that some recovery to Australia’s competitive position (based on currency valuation) commenced as the A$ retreated from its very high values in 2013.

Contrary to the situation for Australia, the graph shows that New Zealand’s overvalued currency was disadvantaging its agricultural exporters in the period prior to 2003, but since that time there has been a turnaround and New Zealand is now one of the most competitive nations included in the research, based on relative currency valuation. This period during which New Zealand’s currency has been...
relatively undervalued has coincided with a period during which the value of New Zealand agricultural exports, particularly dairy products exported to China, have grown significantly.

In order to obtain some assessment of the relationship between exchange rates and the real gross value of agricultural output (RGVAP) for each nation, correlation coefficients were calculated between the two variable. Table 12 shows the overall results for the REER indicator for each country assessed in the Index. The REER results had no significant correlation with the rate of growth of RGVAP.

<table>
<thead>
<tr>
<th>National Regulatory Environment</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.44</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.11</td>
</tr>
<tr>
<td>USA</td>
<td>-0.45</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.27</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.16</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-0.30</td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

It was anticipated that the REER indicator might show some positively correlation with RGVAP, although it is recognised that there are a broad range of factors (including climatic conditions) that can have a major impact on RGVAP, irrespective of exchange rates. It is also relevant to note that for an agriculture sector with a large domestic market and with trade barriers preventing imported products from competing in that domestic market, exchange rates are likely to have less impact on RGVAP that would be the case in an unprotected domestic market, or for a nation heavily dependent on exports.

A further complication with the REER indicator emerges when comparing different national economies. For example, Brazil’s agricultural sector comprises a large share of both national exports and GDP, whereas Australia’s agricultural sector comprises a relatively small share of both national exports and GDP. Therefore, trends in RGVAP can significantly impact the exchange rate in countries like Brazil as opposed to countries with an economy where agricultural trade holds a smaller share of overall trade such as Australia.

It is also important to consider the time lags associated with agricultural production, and the potential that farmers have to change production in response to price changes brought about by changes in exchange rates. For mature agriculture sectors such as those in Australia, New Zealand, the USA and Canada, there is little opportunity to expand the resources utilised by agriculture in response to higher prices. This means that while there might be a commodity price response as a result of a more favourable exchange rate, the opportunity to expand total production volumes may limited. This is not necessarily the case in a developing nation such as Brazil or Ukraine, where additional resources (especially land and water) may be more readily available to utilise in response to price increases associated with a prolonged period of more favourable exchange rates.

Indicator 3 – National Regulatory Environment

The third indicator included as one of the ‘National Economy’ factors was an indicator of the National Regulatory Environment. If the national regulatory environment is more conducive to starting and operating a business then this is an indication that businesses face less red-tape and regulations that impede their competitiveness. It would be anticipated that such an environment is more likely to result
in competitive agricultural businesses than one where change is impeded by regulations and government controls.

Obtaining an objective quantification of the nature of the regulatory environment governing businesses in different nations is not an easy task. The most widely recognised indicator is one based on the results of a survey conducted annually by the World Bank, termed the “Ease of Doing Business Survey”. The results of this survey are used to create a national regulatory environment indicator for each nation. This indicator has been included in the research as it is assumed that the general regulatory environment for businesses in a particular nation also reflects the general business environment for agricultural businesses.

Figure 16 displays the annual results for the National Regulatory Environment indicator for each nations included in the research reported here.

As might be anticipated, the four developed nations included in the research are all considered to have relatively good regulatory environments in which to conduct businesses, and these environments are not perceived to have changed greatly over time. In contrast, the regulatory environments of Brazil and Ukraine are considered to be much less conducive to doing business.

The results of the National Regulatory Environment indicator, as determined by the latest ‘World Bank: Ease of Doing Business’ survey, ranked Australia 10th in the world (see Table 13) in terms of ease of doing business, behind the USA and New Zealand, but well ahead of Canada, Brazil, Ukraine and South Africa. This ranking for Australia represents a slight decline from 8th position in 2007. Unsurprisingly, the other developed nations in the Index have consistently all ranked within the top 20 countries in the world for ease of doing business.
Table 13: Annual world rankings for 'World Bank: Ease of Doing Business'

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>11</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Canada</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>12</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>USA</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Brazil</td>
<td>121</td>
<td>122</td>
<td>127</td>
<td>129</td>
<td>120</td>
<td>126</td>
<td>130</td>
</tr>
<tr>
<td>New Zealand</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Ukraine</td>
<td>128</td>
<td>139</td>
<td>146</td>
<td>142</td>
<td>149</td>
<td>152</td>
<td>137</td>
</tr>
<tr>
<td>South Africa</td>
<td>29</td>
<td>35</td>
<td>32</td>
<td>34</td>
<td>36</td>
<td>35</td>
<td>39</td>
</tr>
</tbody>
</table>

Table 14 shows the correlations between the normalised overall results of the National Regulatory Environment indicator with the RGVAP for each country assessed in the Index. Essentially, the results for the National Regulatory Environment indicator exhibited no significant correlation with RGVAP. This is not unexpected, as the national regulatory environment indicator is essentially static for each individual nation over time, and has only been available for a limited period of time.

Table 14: Correlation between National Regulatory Environment indicator and GVAP

<table>
<thead>
<tr>
<th></th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.03</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.94</td>
</tr>
<tr>
<td>USA</td>
<td>-0.34</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.02</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.57</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-0.64</td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.74</td>
</tr>
</tbody>
</table>

Indicator 4 – Governance Standards

The fourth indicator selected for inclusion as one of the ‘National Economy’ factors was an indicator of Governance Standards. Relatively good governance standards are likely to reduce the potential for abusing entrusted power for private gain, which effectively improves the competitiveness of businesses in sectors such as agriculture. The indicator of Governance Standards used in this research is the World Bank Transparency Index, which that organisation publishes annually.

Figure 17 illustrates the annual results for the Governance Standards indicator for each country included in the research reported here.
Figure 17: Annual results for the Transparency Index.

Australia achieved a score of 81 out of a possible 100 in the latest ‘World Bank: Transparency index’. This score represents a slight decline from scores in the mid to high 80s, which was common prior to 2011.

Of the nations included in the research, New Zealand consistently ranks as the nation with the highest governance standards, while the USA continually ranks poorly amongst developed nations. Of the developing nations, Ukraine and South Africa have constantly been rated quite poorly on this measure and do not appear to be registering any improvement, while Brazil is also rated poorly but has achieved some improvement over recent years.

Table 15 shows the correlation between the overall results for Governance Standards and RGVAP for each country assessed in this index. Essentially, the results for the Governance Standards indicator exhibited no significant correlation with RGVAP. This is not unexpected, as governance standards usually only change very slowly, whereas agricultural output can be quite volatile depending on seasons and markets. There is also a relative limited availability of time-series data associated with this indicator.

Table 15: Correlation between Transparency Index and GVAP

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.38</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.19</td>
</tr>
<tr>
<td>USA</td>
<td>-0.84</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.15</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.42</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.14</td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.56</td>
</tr>
</tbody>
</table>

It is assumed that transparency and the lack of corruption would encourage investment and consequently productivity growth for sectors such as agriculture within a national economy. However,
relatively poor governance standards within a nation might mean that agricultural businesses could underpay labourers, for example, and thereby increase output. In that situation, poor governance standards may increase RGVAP rather than reduce it.

**Indicator 5 – Shipping Connectivity**

The fifth indicator included as one of the ‘National Economy’ factors is *Shipping Connectivity*. The rationale for inclusion of this indicator is that the more shipping options that are available for trading goods overseas the greater the potential there is for businesses, and in particular businesses in the agricultural sector, to competitively participate in international trade.

The *Shipping Connectivity* indicator, as determined by the ‘World Bank Linear Shipping Index’, is heavily influenced by geography and population size. For this reason, New Zealand performs poorly on this index compared with other nations included in this research. Conversely, the United States is ranked significantly higher than the other nations.

Figure 18 displays the annual results for the *Shipping Connectivity* indicator for each nation included in the research.

![Figure 18: Annual results for the Liner Shipping Connectivity Index.](image)

The results of Australia’s *Shipping Connectivity* has risen slightly over time, but remains below the levels recorded for Canada, Brazil and South Africa.
The *Shipping Connectivity* indicator defined by the World Bank has five components:

- number of ships
- their container-carrying capacity
- maximum vessel size
- number of services; and
- number of companies that deploy container ships in a country's ports.

These components will tend to increase with the industrialisation of an economy generally, which makes isolating the effect of trade integration on agricultural production difficult. The lack of correlation with RGVAP in developed economies suggests that growth in *Shipping Connectivity* may be largely symptomatic of separate growth enabling factors surrounding concurrent industrialisation.

In addition, the direction of causal link between *Shipping Connectivity* and RGVAP is not clear. For a nation which has traditionally relied on agricultural exports, it may be the case that the growth of agricultural output has led to improvements in shipping connectivity. Conversely, for a nation in which agricultural products are a relatively minor share of total goods exports, good shipping connectivity would make it easier for the agricultural sector to expand. Consequently, uncertainty associated with the direction of causality may diminish the use of the *Shipping Connectivity* indicator as an indicator of agricultural competitiveness.

Table 16 shows the correlation of the overall results for *Shipping Connectivity* and RGVAP for each nation assessed in the research. It shows there was significant positive correlation between shipping connectivity and RGVAP for the developing nations, which include Brazil, Ukraine and South Africa. There was no significant correlation observed for the developed nations.

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.08</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.03</td>
</tr>
<tr>
<td>USA</td>
<td>0.12</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.64</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.33</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.72</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Table 16: Correlation between the Shipping Connectivity indicator and GVAP**

**Indicator 6 – Quality of Port Infrastructure**

The sixth and final indicator included as part of the ‘National Economy’ factors was *Quality of Port Infrastructure*. This indicator was chosen as it provides an indication of the likely costs (both monetary and time) associated with exporting goods to and from a specific nation.

Figure 19 displays the annual results for the *Quality of Port Infrastructure* indicator for each country included in the research.
Australian ports were rated quite highly in the latest ‘World Bank: Quality of Port Infrastructure’ index, with Australia achieving a score of 5.0 out of 7.0, second only to the score of 5.5 achieved by Canada. The above graph shows the scores for all the nations included in this research, normalised over a range from zero to 100.

As would be expected, developed nations scored higher than developing nations for the Quality of Port Infrastructure indicator. For example, Brazil’s Quality of Port Infrastructure score remains particularly low suggesting that available port capacity has struggled to keep up with industry expansion in that country in trade oriented sectors such as agriculture.

Table 17 shows the correlation of the overall results for Quality of Port Infrastructure and RGVAP for each country assessed in the Index. Australia was the only country that registered a statistically significant correlation between Quality of Port Infrastructure and RGVAP, although given the relatively short timeframe over which data were available, some caution is needed in assessing the implications of this result.

Executive Opinion Surveys serve as the basis for the ‘World Bank: Port Infrastructure Index’, with survey responses taking into account the views of companies involved in many other national economic sectors, such as mining. Therefore, these survey responses may crowd out the prevailing sentiment for specific sectors such as agriculture.

Similar to the discussion on some of the other indicators, the lack of time series data makes it difficult for trends to emerge for the Quality of Port Infrastructure indicator.
Table 17: Correlation between Quality of Port Infrastructure indicator and RGVAP

<table>
<thead>
<tr>
<th></th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.79</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.30</td>
</tr>
<tr>
<td>USA</td>
<td>-0.43</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.11</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.62</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.55</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Indicator 7 – Access to Capital

The seventh indicator included in the research, and the first indicator for the ‘Agriculture-specific’ group of competitiveness factors was *Access to Capital*. The rationale for the inclusion of this factor was that the amount of credit or capital made available by banks to farm businesses within a national economy provides an indication of the growth potential and perceived risks associated with farm businesses in that nation. The indicator was calculated by dividing total lending to each national agricultural sector by the annual gross value added (GVA) for the sector.

Figure 20 displays the results for the *Access to Capital* indicator for each nation included in the research.

![Figure 20: Annual results for the Access to Capital indicator](image)

Australia’s results for the *Access to Capital* indicator shows that debt as a proportion of GVA has increased significantly from levels recorded in the early 2000s. New Zealand’s ratio of agricultural debt to GVA nearly doubled between 2007 and 2013, and is the highest ratio among the nations for which data were available. No data were available for South Africa or Ukraine.
United States debt to GVA levels remain low relative to other developed nations. However, rather than indicating an unwillingness of the banking sector to provide finance for agricultural businesses in the USA, this may be a reflection of the prevalence of leasing arrangements on fully owned land and the availability of heavily subsidised multi-peril farm insurance programs, both of which may suppress and distort the requirement for bank finance by farm businesses.

Table 18 shows the correlation of the overall results for Access to Capital and RGVAP for each country assessed in the Index. The results for the Access to Capital indicator showed no significant correlation with the index of RGVAP.

It was assumed that debt levels in the agricultural sector would correlate positively with RGVAP as lenders would react to sector performance by increasing or decreasing their investment depending on business conditions. Unfortunately, a lack of robust data for all the relevant jurisdictions and over an extended period of time have limited the utility of this indicator.

Recent concerns for Australian agricultural debt levels and subsequent government subsidised loans show some of the limitations of capital availability as a measure of agricultural competitiveness. Additionally, there are variations in capital structures between nations such as that observed between the US, Brazil and Australia. These variations further constrain the usefulness of this indicator.

Conceptually, issues pertaining to investment timelines and short term fluctuations due to seasonal fluctuation in GVA may also cause distortions.

**Table 18: Correlation between Access to Capital indicator and RGVAP**

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.10</td>
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<tr>
<td>Canada</td>
<td>0.35</td>
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<tr>
<td>USA</td>
<td>-0.59</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.42</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.02</td>
</tr>
<tr>
<td>Ukraine</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
</tr>
</tbody>
</table>

**Indicator 8 – Agricultural Input Efficiency**

The eighth indicator in the overall Index and the second indicator for the ‘Agriculture-specific’ competitiveness factor was Agricultural Input Efficiency. This indicator was calculated by dividing the value of a nation’s agriculture GVA by the value of labour and working capital (land) that was used to produce that GVA.

The more efficient that a national agriculture sector is in generating GVA for each unit of labour and fixed capital used, the more competitive farm businesses in that agriculture sector are likely to be relative to farm businesses in other nations that do not have a similar level of efficiency.

Figure 21 displays the results for the Agricultural Input Efficiency indicator for each nation included in the analysis.
Since 1962, the growth in Australia’s *Agricultural Input Efficiency* indicator, as measured by the ratio of GVA to primary inputs (labour and working capital) has lagged that of other countries assessed in the Index.

Apart from New Zealand, which has seen relatively high levels of growth in the *Agricultural Input Efficiency*, the indicator has increased at relatively slower rates for the developed nations included in the analysis, when compared with the rates observed for developing nations.

Table 19 shows the correlation of the overall results for *Agricultural Input Efficiency* and RGVAP for each country assessed in the research. With the exception of the USA, there was a statistically significant correlation observed between *Agricultural Input Efficiency* and agricultural RGVAP (excluding Ukraine for which no available data was found).

**Table 19: Correlation between the Agricultural Input Efficiency indicator and GVAP**

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.56</td>
</tr>
<tr>
<td>Canada</td>
<td>0.80</td>
</tr>
<tr>
<td>USA</td>
<td>0.29</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.91</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.78</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.92</td>
</tr>
</tbody>
</table>

It was assumed that improvements in a nation’s *Agricultural Input Efficiency* indicator would mean that the agriculture sector is becoming more productive and profitable, and hence there would be a strong incentive for owners of agricultural businesses in that nation to expand their output. This is only part of a bigger picture, however, because it is possible that if this ratio was increasing at a relatively faster rate for other sectors of a national economy, then the opportunity for agricultural businesses to
invest and expand output may be constrained. This qualification noted, the above results indicate a close association, if not a causal relationship, between the indicator and RGVAP.

The weak correlation between Agricultural Input Efficiency and GVAP in the US is somewhat perplexing. However, competition for resources from other sectors in the US may offer an explanation. The real gross value of agricultural production in the US declined from 1990 through to the early 2000s before rising strongly post 2008, when other sectors of the US economy experienced slow or negative growth due to the effects of the Global Financial Crisis and its subsequent implications.

The loose classification and reporting practices associated with labour costs within the different sectors confounds the Agricultural Input Efficiency measure to some degree. This seems to be true across a range of nations, particularly in regard to cash payments, the costing of the illegal use of labour, and the methods used to account for the unpaid labour input from family members.

**Indicator 9 – Quality of Natural Resources**

The ninth indicator in the overall Index and the third indicator for the ‘Agriculture-specific’ competitiveness factors was Quality of Natural Resources. The suitability of land and the availability of water and climatic conditions can have a major impact on agricultural production, it was therefore apparent that an indicator of the quality of natural resources should be included in any assessment of agricultural competitiveness.

Figure 22 displays the annual results for the Quality of Natural Resources indicator for each country included in the research. As noted earlier, there are no comprehensive and objective measures of this factor available at a national level, so it was therefore decided that average cereal crop yields would be used as a proxy indicator for this factor. Cereals crops are common to all the nations included in the analysis, and the average national yield provides an indicator of the quality of the natural resource base (both soil and rainfall) that is available to farmers within that nation. It is acknowledged that cereal yields can be affected by the level of inputs (such as fertilisers and chemicals) used, but even the use of these tends to be limited by the overall quality of soil and the reliability and quantity of rainfall.

Cereal yields can also be affected by innovation and technology adoption, and this may distort the extent to which it is a true indicator of soil quality and rainfall reliability and availability. To some extent this is mitigated by the fact that most R&D in cereals is carried out by public research agencies, and there are likely to be considerable international spillovers, especially over an extended timeframe, meaning that farmers in most nations will have access to innovations reasonably quickly. It is also likely that the adoption of new innovations may adjust the rate of change of cereal yield, but may not change the relativity of yields between nations to any great extent, due to the suitability of soils and rainfall being the main limiting factor.

The use of cereal yields as an indicator of natural resource quality is also appropriate, given that it is sensitive to changing landuse – such as when cereal crop production expands to more marginal production areas. It is difficult to accommodate such changes in a static indicator based, for example, on mapped areas of particular soil types.
Cereal yield, which has been used as a proxy for Quality of Natural Resources, showed roughly similar positive growth trends over the period for all countries except Australia where growth has lagged since the late 1990s.

New Zealand and the US maintained the highest cereal yields over the period despite growth in other nations suggesting the underlying quality of unimproved land remains critical to cereal yield in some countries.

Table 20 shows the correlation of the overall results for Quality of Natural Resources and RGVAP for each nation assessed in the research. The Quality of Natural Resources indicator, as measured by average cereal yields, shows significant positive correlation with RGVAP for all countries except Australia.

In Australia, the situation might be complicated by the fact that for most of the period from 2003 to 2010, the Murray-Darling Basin (an important cereal producing area) experienced a prolonged drought, which also coincided with a period during which agricultural productivity growth stagnated. Despite this, livestock production and exports expanded over this period, contributing to higher RGVAP than would otherwise have been the case.

Table 20: Correlation between the Quality of Natural Resources indicator and RGVAP

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.35</td>
</tr>
<tr>
<td>Canada</td>
<td>0.78</td>
</tr>
<tr>
<td>USA</td>
<td>0.42</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.94</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.83</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.77</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Indicator 10 – Technology Adoption

The tenth indicator included in the overall Index and the fourth indicator for the ‘Agriculture-specific’ competitiveness factors was Technology Adoption. The rationale for the inclusion of this indicator is that the rate of adoption of new innovations and technologies in a national agriculture sector is widely considered to be an important factor in achieving productivity growth, and therefore maintaining or improving national agricultural competitiveness.

As noted earlier, there are no readily available, objective international indicators of technology adoption rates in agriculture. Consequently it was decided to use a proxy measure for this factor, which was the annual percentage rate of increase in cereal and livestock yields for each of the nations included in the research. Livestock commodities included in the indicator were pork, chicken meat, milk, beef and sheepmeats. The percent annual increases in each of these were averaged for each nation, and combined to create an overall national livestock indicator. This was then combined with the results for the annual percentage increase in cereal yield for the nation on an equal weighting for livestock and crops to create the overall national indicator. The crop results were smoothed using the average of three years to calculate a ten-year rolling average to reduce short-term volatility in the indicator.

Figure 23 displays the annual results for the Technology Adoption indicator for each country included in the analysis.

Figure 23: Annual results for the Technology Adoption indicator.

The results for Australia’s Technology Adoption indicator show a significant decline over the period from 1997 to 2008, during which time Australia slipped from a relatively high ranking to the lowest of all nations included in the analysis. There is no doubt the impact of the prolonged drought in southern Australia had some impact on the rate of increase in both crop and livestock yields over this period (certainly for grazing livestock) although the decline in this indicator extends for a longer period that just the drought years.

Seasonal conditions have the potential to distort the Technology Adoption indicator, although trends reflecting improved practices appear to have emerged. For example, Brazil scored relatively well for
this indicator from the mid-1990s onwards, which coincided with the dramatic growth in the value of output of both crops and livestock products for that nation.

Table 21 displays the correlation between the national Technology Adoption indicator and RGVAP for each nation assessed in the research. A positive correlation between the indicator used for Technology Adoption and RGVAP was found for the US, Ukraine and South Africa, however, the short period for which data is available for Ukraine casts doubt on the result for that country.

**Table 21: Correlation between the Technology Adoption indicator and GVAP**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.33</td>
</tr>
<tr>
<td>Canada</td>
<td>0.57</td>
</tr>
<tr>
<td>USA</td>
<td>-0.17</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.39</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.21</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.74</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.77</td>
</tr>
</tbody>
</table>

**Indicator 11 – Research and Development Investment**

The eleventh indicator in the overall analysis and the fifth indicator for the ‘Agriculture-specific’ competitiveness factors was Research and Development Investment. The level of investment in agricultural research and development that is occurring within a national agriculture sector was considered likely to be an important contributing factor to both the current and future rate of productivity growth, and hence the competitiveness of the national agriculture sector.

The indicator was calculated by summing the total national investment in agricultural research and development over a previous fifteen year period, and expressing that as a ratio of current year gross value of agricultural output. The fifteen year timeframe was selected to account for the recognised lag that occurs between R&D investment and subsequent innovation adoption, with the fifteen year period pragmatically selected on the basis of data availability.

Figure 24 shows the annual results for the Research and Development Investment indicator for each nation included in the analysis.
Figure 24: Annual results for the Research and Development Investment indicator

Canada appears to spend more than three times as much as most other nations on agricultural R&D, based on an agricultural Research and Development (R&D) expenditure to GVA ratio. With the exception of New Zealand, R&D investment has been declining relative to agricultural GVA for the countries included in the Index.

Australian Research and Development Investment levels have declined since the year 2000, based on the data available.

Table 22 shows the correlation between Research and Development Investment and RGVAP for each nation included in this research. Significantly negative correlations were registered between Research and Development Investment and RGVAP for Canada and the US. However, the ratio is impacted negatively by year on year fluctuations in GVA and is liable to result in a negative correlation during above average seasons.

Table 22: Correlation between the Research and Development Investment indicator and RGVAP

<table>
<thead>
<tr>
<th></th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.50</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.99</td>
</tr>
<tr>
<td>USA</td>
<td>-0.91</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.58</td>
</tr>
<tr>
<td>Ukraine</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
</tr>
</tbody>
</table>

It was assumed that the Research and Development Investment ratio would show a positive correlation with RGVAP as effects of the prior 15 year cumulative R&D expenditure filters through to the RGVAP. The significant negative correlations for the US and Canada are concerning and suggest there are deficiencies with the methodology for measuring this indicator.
Accounting for the lag in returns to R&D expenditure poses a significant challenge, especially when forming a generic index. Specialisation of agriculture also effects R&D efficacy, particularly for smaller nations. For example, the dominant role of the dairy industry in New Zealand means that R&D spending in that area will often have a disproportionately large effect on the RGVAP.

A lack of time series data and a plethora of data quality issues in compiling R&D investment estimates, especially in relation to Australia, suggests a need for caution in drawing assumptions from the results shown here.

**Indicator 12 – Marketing Efficiency Ratio**

The twelfth indicator in the overall Index and the sixth and final indicator for the ‘Agriculture-specific’ competitiveness factor is the *Marketing Efficiency Ratio*. The *Marketing Efficiency Ratio* provides an indication of a nation’s competitiveness in supplying agricultural products from the farmgate to major international import markets. It is calculated as the ratio of farmgate commodity prices received by farmers, to the price of those same commodities at major international market destinations. A relatively high ratio indicates either that a nation produces above average quality products, has a highly efficient supply chain, or obtains favourable market access in destination markets.

Figure 25 displays the annual results for the *Marketing Efficiency Ratio* indicator for each country included in the Index.

![Figure 25: Annual results for the Marketing Efficiency Ratio indicator](image)

Farmers in Canada had traditionally experienced a relatively high marketing ratio for their products, perhaps a reflection of their proximity to major markets such as the USA. Since 2000, there has been a marked convergence in this indicator for the nations included in the analysis. This is possibly a result of the dramatic growth that has occurred in international agricultural trade since that time, which has undoubtedly resulted in the development of increasingly efficient supply chains, and has also enabled agricultural trading companies to source products globally. The result is undoubtedly a reduction in the importance of proximity to markets as a competitive factor for any specific nation.
Table 23 shows the correlation between the overall results for Marketing Efficiency Ratio and RGVAP for each country assessed in the research. Canada and Ukraine exhibit negative and positive correlations, respectively, between the Marketing Efficiency Ratio indicator and RGVAP.

Table 23: Correlation between the Marketing Efficiency ratio indicator and RGVAP

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.27</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.83</td>
</tr>
<tr>
<td>USA</td>
<td>-0.55</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.24</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.33</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.65</td>
</tr>
<tr>
<td>South Africa</td>
<td>-0.48</td>
</tr>
</tbody>
</table>

A positive correlation between the Marketing Efficiency Ratio and GVAP was expected for a number of reasons. These reasons included efficiency of export supply chains and international market access. In the case of a developing nation such as Ukraine, the significant correlation may also reflect an increase in quality control and capabilities to meet commodity specifications which incentivised production.

Composite competitiveness index

Analysis at the individual indicator level has identified that there are varying degrees of correlation between each of the indicators selected, and national RGVAP. This is to be expected, as some of the indicators chosen are relatively static over time (such as shipping connectivity), while others are more dynamic (real effective exchange rates), and it is widely understood that a nation’s agricultural competitiveness is likely to be associated with the impacts of a combination of different factors, rather than a single factor.

To further examine the significance of the various indicators chosen (either in isolation or in combination) as predictors of national agricultural performance, a composite national index was created by averaging national scores for all twelve of the indicators chosen for inclusion in the agricultural competitiveness index discussed in the previous section. Each of the twelve indicators was allocated an equal weighting in the combined index. The results of this analysis are displayed in Figure 26.
The resulting indicator has a number of limitations due to the lack of availability of data relevant to all the twelve factors included in the composite index, especially in the case of the developing nations included in the analysis. That qualification noted, New Zealand stands out as the national agriculture sector which has consistently ranked highest in an index composed of the twelve indicators utilised in this analysis. Both the USA and Canada have also recorded persistently high scores over time. Australia has persistently ranked below these three nations over the past decade, with the gap between the leading three nations and Australia appearing to increase over the past five years, a period during which the result for Australia has been relatively static.

Australia’s relatively low indicator scores for the agriculture-specific competitiveness factors have been the main limitations. Quality of Natural Resources, Input Use Efficiency, and Research and Development Investment were found to be key indicators limiting Australia’s score, utilising this index. The score achieved by Brazil appears to have declined over recent years, although a lack of data for a number of indicators limits the robustness of this result. Comprehensive data for all indicators has only been available since 2007 for Brazil, and for a similarly limited period for the other developing nations included in the analysis. Table 24 displays the simple correlation between each nation’s aggregate unweighted score and the index of RGVAP, highlighting the weak, variable and often seemingly perverse relationship between them at the national level.

\textit{Table 24: Correlation between the unweighted aggregate index and RGVAP}

<table>
<thead>
<tr>
<th>Country</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>-0.56</td>
</tr>
<tr>
<td>Canada</td>
<td>0.36</td>
</tr>
<tr>
<td>USA</td>
<td>-0.20</td>
</tr>
<tr>
<td>Brazil</td>
<td>-0.80</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.39</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-0.19</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.04</td>
</tr>
</tbody>
</table>
Validating indicator results against national agricultural performance

The critical issue from the perspective of a competitiveness index is whether the national agriculture sector performance predicted by the index matches the performance of the agriculture sector in question. The normal approach in cases where multiple factors are being combined into a single aggregated index is to simply add or average the results for each of the factors using an equal weighting. Other alternatives include utilising statistical analysis to develop differentiated weightings that can be used to combine individual factors into a single index figure.

Irrespective of the methodology used to calculate a composite or aggregated index, a key question for the research reported here is the extent to which the results of the calculated competitiveness index reflect the actual performance of the national agriculture sector in question. As discussed earlier, it was decided that the appropriate ‘measure’ of performance in this instance should be changes in the real gross value of agricultural production for each of the nations included in the analysis.

Unweighted aggregated index

The initial validation analysis involved a comparison between the aggregate competitiveness indices for each nation (with each of the twelve factors given an equal weighting) for each year, and the real gross value of agricultural production index for each nation.

The results for each of the twelve factors for each of the seven nations were averaged and aggregated into a single score. This was then compared with the annual RGVAPs for each nation. The results of that comparison are shown in Figure 27.

![Figure 27. Relationship between national agricultural competitiveness index and RGVAP.](image)

The results indicate a low and slightly negative correlation between the aggregated competitiveness index for each nation and each nation’s RGVAP (correlation coefficient = -0.18).

The data was also disaggregated into developed and developing nations, as it was evident from Figure 27 that there was a distinct difference between the results applicable to the two groups of nations. Figures 28 and 29 display the results separately for the developed and developing nations, respectively.
The correlation coefficient between the unweighted national agricultural competitiveness index and RGVAP for developed nations was 0.49, while the correlation coefficient for the developing nations was -0.12. These results highlight that while the calculated competitiveness index (with each of the twelve factors equally weighted) appears to perform reasonably well in the case of the developed nations and South Africa, it does not do so in the case of Brazil and Ukraine. This is consistent with the findings of other similar research at a national economy level referenced earlier (such as the Global
Competitiveness Index) which identified that the importance of different factors changed as a nation went through different stages of economic development.

**Weighted aggregated index**

A second approach to developing an agricultural competitiveness index is to apply different weights to different factors, with the aim of achieving a weighted composite index that more closely reflects agricultural competitiveness as reflected in growth in RGVAP over time. In order to allocate appropriate weightings to the twelve factors available to be included in a national index, multiple linear regression was utilised, with RGVAP as the dependent variable.

In the first instance, annual data for all seven nations were included in the analysis. Table 25 displays the results of this analysis. The analysis resulted in a total of seven factors being selected for inclusion in the best-fit equation to predict a nation’s RGVAP performance, three of these being economic factors and the remaining being agriculture specific.

Table 25. Factors and related coefficients arising from multiple linear regression analysis.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
<td>-0.567</td>
</tr>
<tr>
<td>Regulatory environment</td>
<td>-0.538</td>
</tr>
<tr>
<td>Port infrastructure</td>
<td>-0.689</td>
</tr>
<tr>
<td>Capital availability</td>
<td>0.390</td>
</tr>
<tr>
<td>Natural resources</td>
<td>0.179</td>
</tr>
<tr>
<td>Technology adoption</td>
<td>0.379</td>
</tr>
<tr>
<td>Marketing efficiency</td>
<td>-0.407</td>
</tr>
<tr>
<td>Constant</td>
<td>204.87</td>
</tr>
</tbody>
</table>

The resulting multiple correlation coefficient between predicted and observed RGVAP was 0.725, indicating that the prediction equation accounted for approximately 52% of the observed variance in RGVAP.

This result needs to be treated with some caution, however, as it is likely the result is not a consequence of a cause and effect relationship between the identified indicators and RGVAP. This is reinforced by the observation that in the case of exchange rates, regulatory environment, marketing efficiency and port infrastructure, the calibration coefficients all have a negative sign, indicating that the relationship between each of these and RGVAP is in the reverse direction to what would be anticipated. That is, if the relationship expressed by the above correlation coefficients is to be believed, RGVAP should increase when exchange rates, the regulatory environment, port infrastructure and marketing efficiency all change in an adverse manner.

Figure 30 is a plot of observed and predicted annual RGVAP for all seven nations included in the analysis, with predicted RGVAP calculated utilising the above coefficients for the seven listed factors.
Figure 30. Predicted and observed RGVAP for all nations, - weighted index.

The same analysis was then repeated separately for the developed and developing nations included in the analysis, to see whether separating the two groups resulted in any improvement in the relationship between observed and predicted outcomes. Table 26 displays the factors and associated coefficients generated for the developed nations.

Table 26 Factors and related coefficients arising from multiple linear regression analysis, developed nations.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>-1.29</td>
</tr>
<tr>
<td>Capital availability</td>
<td>0.50</td>
</tr>
<tr>
<td>Input efficiency</td>
<td>0.26</td>
</tr>
<tr>
<td>R&amp;D investment</td>
<td>-0.18</td>
</tr>
<tr>
<td>Marketing efficiency</td>
<td>-0.30</td>
</tr>
<tr>
<td>Constant.</td>
<td>204.84</td>
</tr>
</tbody>
</table>

The resulting multiple correlation coefficient between observed and predicted RGVAP, where predicted RGVAP was calculated utilising the above factors and coefficients was 0.78, meaning that approximately 61% of the variance in observed RGVAP was explained by the factors identified above – a slight improvement in comparison with analysis involving data for all nations. A plot of observed and predicted RGVAP using the above factors and coefficients is shown as Figure 31.
Again, the result needs to be treated with some caution, as they suggest the relationship between the observed factors and RGVAP is often the reverse of what might be normally anticipated.

The same analysis was then repeated for the three developing nations included in the analysis, namely Brazil, Ukraine and South Africa. The results are displayed in the following table and figure.

Table 27. Factors and related coefficients arising from multiple linear regression analysis, developing nations.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>-0.604</td>
</tr>
<tr>
<td>Natural Resource quality</td>
<td>2.76</td>
</tr>
<tr>
<td>R&amp;D investment intensity</td>
<td>-1.99</td>
</tr>
<tr>
<td>Constant.</td>
<td>97.4</td>
</tr>
</tbody>
</table>

The resulting multiple correlation coefficient between observed and predicted RGVAP was 0.86, meaning that almost 74% of the variation in RGVAP between the three nations was explained by the prediction equation arising from the results displayed in the above table.

While the relationship between RGVAP and natural resource quality as expressed by the sign of the calculated correlation coefficient is as would be anticipated, the relationship between RGVAP and governance and R&D investment intensity is essentially the opposite direction to what would normally be expected. This indicates that the resulting calibration equation is unlikely to be robust if used for prediction purposes.
Figure 32 Predicted and observed RGVAP for developing nations, - weighted index.

A limitation associated with this analysis, particularly in relation to developing nations, is the lack of availability of comprehensive data for all the twelve indicators included in the analysis, and for the annual gross value of agricultural production. The limited number of years over which comprehensive data is available severely limits the robustness of the results, and means that the application of the index generated in this analysis to other nations would likely result in much less prediction accuracy when using it to predict the performance of a specific national agriculture sector.
References


Assessing the competitiveness of Australian agriculture

by Mick Keogh, Adam Tomlinson and Mark Henry

RIRDC Publication No 15/054
RIRDC Project No PRJ-009740