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Cultivating Success: The Role of Institutions, Policies and Investments in Driving Rural Transformation in Australia

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ABSTRACT

Australia's agricultural sector has experienced a remarkable resurgence in economic growth since the late 1970s, effectively reversing decades of stagnation following World War II. At the heart of this resurgence lies the pivotal role of agricultural total factor productivity (TFP) growth, which has been 1.4% a year accounting for more than two-thirds of the growth in agricultural output. Crucially, government interventions, encompassing a range of institutions, policies, and investments (IPIs), have significantly contributed to this transformation process. These IPIs include deregulation, substantial investments in research and development, and effective water management. This paper reviews agricultural development in Australia since the 1950s and the profound role of IPIs on agricultural TFP. By drawing valuable insights from the Australian experience, we shed light on the pivotal role that governments can play in fostering agricultural GDP growth, sustainability, and resilience within an ever-evolving global landscape.

JEL Classification: Q12, Q18, O32

1 | Introduction

In many developing economies, rural transformation is essential for economic development. Initially, agricultural sectors are anchored in staple grain production—rice, wheat, and maize—to ensure food security and meet the basic nutritional needs of growing populations. The scope of non-agricultural employment is limited, confining most of the rural labour force to farming and to low incomes. However, when there is a substantial improvement in productivity (e.g., the consequence of reform of some sort, or the result of an investment in research and development), agricultural sectors become more commercialised and diversified. There is a shift in the structure of agricultural production towards higher proportions of high-value commodities, and rural labour is freed up for off-farm activities. Consequently, agricultural diversification and the expansion of non-farm employment opportunities increase rural incomes and revitalise rural economies, and the share of agriculture in output and employment falls (Huang and Rozelle 2018; International Fund for Agricultural Development (IFAD) 2016). The changing structure of agricultural output and the transition of employment are the essential elements of rural transformation (Timmer 2017; International Fund for Agricultural Development (IFAD) 2020; S. G. Fan and Cho 2021).

The evolution in structure of agricultural output and the transition of employment in developing economies usually require support from the design of better institutions, the application of specific policies and improved investments (the IPIs). Depending on different initial endowment conditions, stage of development and emerging challenges, different items in the set of IPIs contribute to different goals. For example, some IPIs can bolster agricultural productivity through the adoption of technological innovation and modern farming practices, contributing to a more stable food supply while generating surpluses for market sales (Berdegué et al. 2013; Huang and Rozelle 2018). Other IPIs can encourage the diversification of production, shifting from a reliance on staple grains to a broader range of high-value crops, which can enhance farmers' incomes and provide a buffer against market volatility (International Fund for Agricultural Development (IFAD) 2016). Various IPIs can also promote the expansion of off-farm employment by investing in rural infrastructure, connecting rural areas to broader economic opportunities and fostering the growth of non-farm sectors (S. G. Fan and Cho 2021). It also follows that different IPIs are relatively more important at the different stages of transformation.

Agriculture is an important component of the Australian economy, and its path of development and rural transformation differs substantially from that of EU countries. Unlike those economies, the share of agriculture in output (or GDP) in Australia persisted as incomes grew, remaining at about 20%–30% for at least a century from the 1850s to the 1950s (Anderson 2024). Factors contributing to this steady share of agriculture in output up to the mid-1950s included Australia's natural resource endowments, which determined its comparative advantage in agriculture and impacted industrialisation. Global trade conditions also played a role, including the decline in trade costs. But following this period, there was a dramatic fall in the agricultural share of output to its current level of about 2.3% from the 1970s onwards. The employment share of agriculture also fell, for example, from 6.4% in the mid-1980s to just over 2% in 2023–24. We discuss later the significance of this situation in which agriculture's output share exceeds the employment share.

Our focus in this paper is to explore the patterns, characteristics and consequences of agricultural development and rural transformation in Australia and its underlying drivers since the mid-1950s.[1] Significant changes in several IPIs have taken place, but only after the 1970s, which influenced the path of rural transformation. Our discussion here will cover several issues related to the reforms linked to IPIs and their economic impacts. With respect to institutional arrangements, we review trade reforms applied to agricultural products at the border, as well as the regulation of domestic markets. Regarding public policies, we discuss agricultural R&D policies, their reforms in the 1980s and the impact on agricultural Total Factor Productivity (TFP) growth. Additionally, we also review some institution arrangements and investment initiatives that are evident in the policy applied to water resources and to research and development.

The next section provides more detail on the development in the agricultural sector in the post-war period in Australia. We then turn to topics related to markets for agricultural products, research and development, and the treatment of water resources. In all cases, there are elements of institutional developments and of policy, as well as investment for the latter two items.

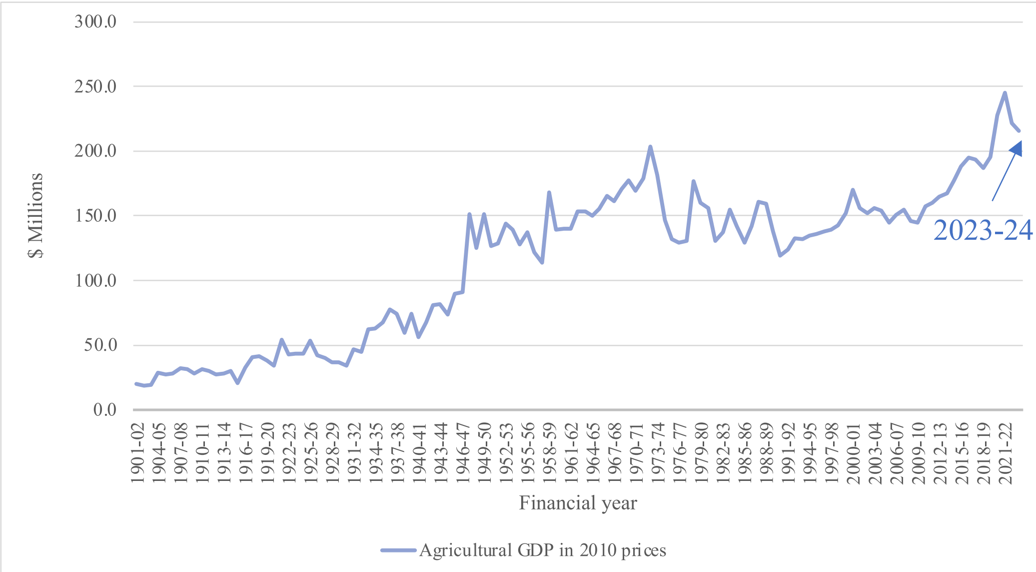
2 | Agricultural Development Over the Post-War Period in Australia

Agricultural output in Australia has grown rapidly over the past 7 decades. Between 1948–49 and 2023–24, the value added of agricultural production, measured in 2010 constant prices, rose from AUD $125.1 million to AUD $215.4 million, at an average annual growth rate of 2.3% as shown in Figure 1 (Butlin 1985; Australian Bureau of Statistics, ABS 2024). However, the trajectory has not been linear. A two-decade decline in agricultural GDP of around 25% was observed throughout the 1970s and 1980s, partly due to unfavourable international market conditions and also to domestic factors, the mining upturn and the growth of services (Anderson 2024).

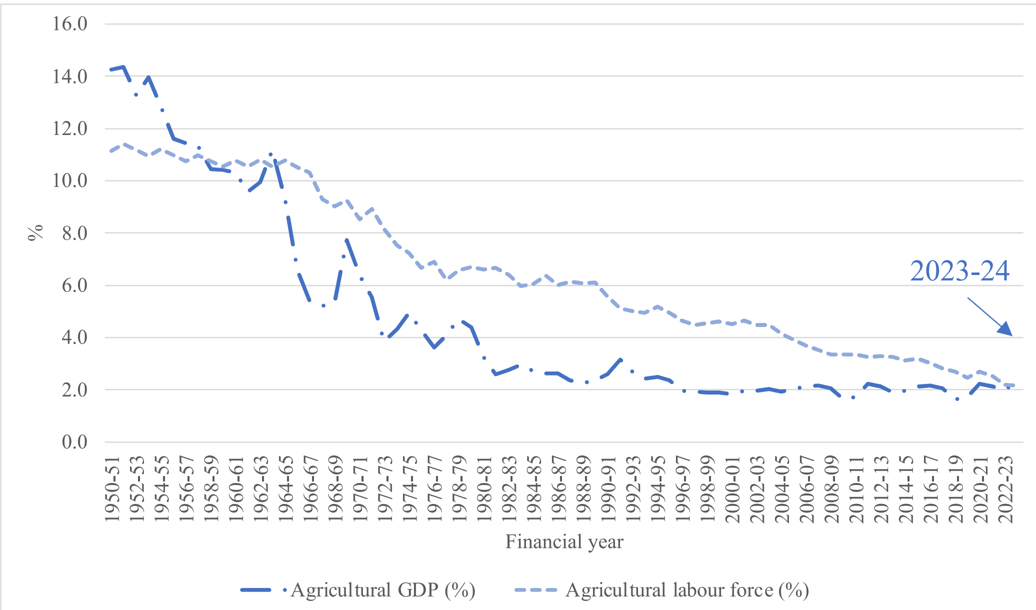
Despite the rapid growth in agricultural output, the share of agriculture in national output fell steadily before the 1990s, from 14.3% in 1950–51 to 2.3% in 1989–90, and thereafter remained stable at around 2.1% from the 1990s to the 2000s, before recovering to 2.3% in 2023–24. During the same period, the share of agricultural employment in the overall economy also declined substantially, from 11.2% in 1949–1950 to 6.1% in 1989–1990, and continued to fell to 2.2% in 2023–2024. While the long-term trend was downward, there were forces operating on agriculture from different directions. The decline was exacerbated by slow productivity growth performance in the 1960s and 1970s (discussed further below). An offset was provided by the improvement in agricultural prices since the late 1960s, and eventually by the consequences of policy reforms from the 1970s (see Figure 1).

After the two-decade stagnation, agricultural output grew more steadily from the late 1980s. Also involved was a gradual change in the output structure. As shown in Figure 2, the output structure shifted from low-value commodities such as coarse grain and wool to high-value products, including horticulture, cash crops, and dairy products etc. Between 1989–90 and 2022–23, the share of other crop and livestock products, particularly fruits, vegetables, dairy and other animal products, in total agricultural output value has increased from less than 30% to more than 40%. However, the production of coarse grains, wool and livestock meat continues to dominate the industry due to growing international food demand and Australia's comparative advantage in producing land-intensive products. In 2022–23, the proportion of these products in overall agricultural output value was still over 60%, although it fell from its original level of 80% in the 1970s. More than two-thirds of these crop and livestock products are produced for and exported to the international market. That is, the drivers of output composition were less related to the growth of and change in composition of domestic demand, as in the case of rural transformation in developing economies discussed above.

Agricultural total factor productivity (TFP) growth, defined as aggregated agricultural output growth minus input growth representing agricultural technology progress and efficiency improvement, is regarded as the most important driving force underlying agricultural output growth over the past 4 decades



(a) The trends in agricultural GDP, 1901-02 to 2023-2024



(b) Australia's agricultural share in GDP and labour force, 1950-01 to 2023-2024

FIGURE 1 | Long-term agricultural growth and rural transformation in Australia. The 'constant price' series is constructed by deflating the corresponding current price GDP series using the GDP implicit price deflator from the expenditure account, with 2010 as the base year. The deflator is applied for the period 1959–60 to 2023–24, as reported in *Table 5: Expenditure on Gross Domestic Product (GDP), Implicit Price Deflators*. For 1901–02 to 1958–59, a historical GDP deflator compiled from the Year Book and Butlin (1985) is used. *Sources:* Compiled by authors based on data from Butlin (1985) for 1901–1938, Year Book Australia (1940-1960) for 1939–1958, and Australian Bureau of Statistics (2024) for the period from 1959 onwards.

(Agriculture and Australian Bureau of Agricultural and Resource Economics and Sciences. ABARES 2024). Between 1948–49 and 2021–22, TFP for all agriculture in Australia has grown at a rate of 2.0% per year (see Figure 3a, where agricultural TFP at 2005–06 is normalised as 100), surpassing that of over half of other OECD countries for the same period. The rate of growth accelerated from the late 1970s, averaging at 2.2%, and then fell to 0.6% between 2001–02 and 2022–23. Despite a slowdown since the 21st century, the long-term growth in agricultural TFP accounted for more than two-thirds of agricultural output growth since the late 1940s, a period associated with the structure change in agricultural products towards the higher-value items and through resource reallocation among farms of different productivities (Mullen and Cox 1995; Sheng 2017).

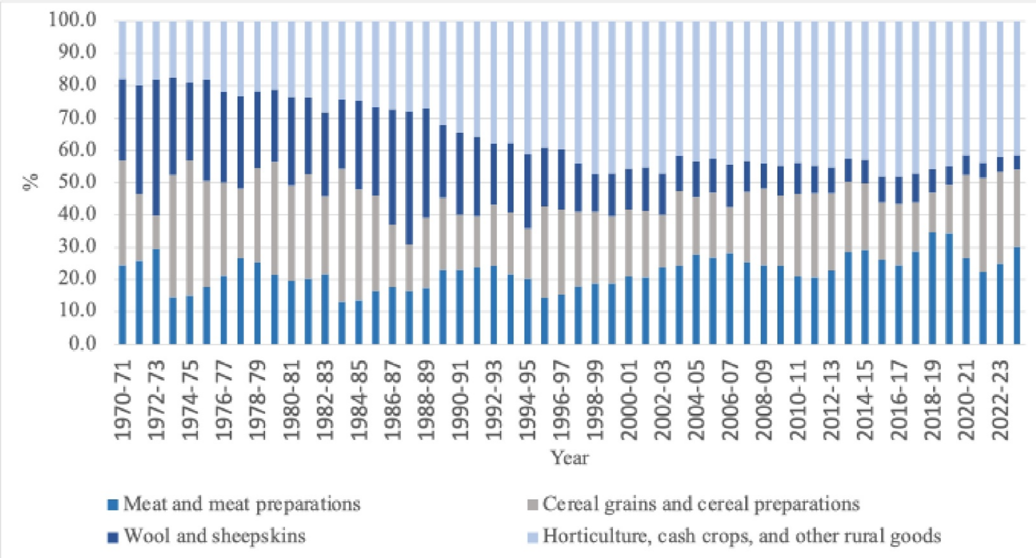


FIGURE 2 | Structural changes of Australian agriculture commodities, 1971 to 2024. *Source:* Compiled by authors based on data from ABARES Australian Agricultural Productivity Database (2023) and Australian Bureau of Statistics (2024).

When the TFP estimates are made by agricultural sectors using the Australian Agricultural and Grazing Industry Survey (AAGIS) and Australian Dairy Industry Survey (ADIS) farm survey data since the late 1970s—as done by ABARES—TFP growth for livestock and dairy products is lower than that for coarse grains, although both sectors have experienced a slowdown in TFP growth in the recent 2 decades (partly due to climate change and frequent droughts).[2] For example, ABARES TFP estimates for crop specialists find an annual average growth rate of 1.6% from 1977–78 to 2022–23, while those for the livestock and dairy specialists have averaged 1.1% and 1.2% per year, respectively, over the same period (see Figure 3b). The difference in TFP growth between crop and livestock industries change the output structure of agriculture and the resource reallocation.

O'Donnell (2014) decomposed aggregate TFP growth at the national level into four factors from another perspective. Applying this framework, TFP in the agriculture, forestry, and fishing sector increased by 26.3% between 1995 and 2019. This growth was significantly influenced by technical progress (12.4%), technical efficiency gains (5.5%), and improvements in scale and mix efficiency (8.3%). Technical efficiency gains and scale and mix efficiency refers to productivity gains resulting from cross-farm resource reallocation and adjustment in the scale of operations (or changes in the output mix or the input mix), directly relating to structural change within the production system through reallocating resources or altering input/output proportions. Consistently, although focussing solely on the dairy industry, Sheng et al. (2017) found that TFP growth was linked to a reallocation of resources from less productive to more productive farms—a process that embodies a mechanism of structural change.

In addition to increasing agricultural output and changing output structure, agricultural TFP growth has also improved the competitiveness and profitability of Australian farmers, facilitating economic structural transformation. From 1969–70 to 2018–19, agricultural labour income increased by 11.1 times (at 2010 constant prices), which was among the highest in OECD countries (Sheng et al. 2020; Fuglie and Rada 2019) (see Figure 4).

Major driving forces in TFP growth were technological change and efficiency improvement (O'Donnell 2012; Sheng 2017). The former is mainly driven by domestic agricultural R&D investment and international technology spill-in, whereas the latter is driven by technology adoption and deregulation-related resource reallocation. We will discuss this issue further below. Other important drivers also included land consolidation and on-farm capital/materials deepening, and industrial structure adjustment (towards more commercialised and specialised farms). Between 1949–50 and 2022–23, the total number of farms declined by two thirds, from 80,000 to less than 20,000, with average land area per farm now being around 188.5 ha. Underlying all the transformation process, market-based reforms with various IPIs have played an important role as we explain below.

Finally, agricultural TFP growth has also facilitated rural transformation, through reallocating labour from agriculture to non-agricultural sectors. As is shown in Figure 1, there is roughly even shares of employment and output in economy (around 2.2% of the workforce and around 2.3% to the GDP in 2023–24).[3] This is possible because of TFP growth contributing to efficiency of input use (i.e., labour) in agriculture, which has also helped reallocate agricultural labour to other sectors. Throughout the post-war period, agricultural TFP growth in Australia saved up to 34% of agricultural labour and facilitated rapid growth in employment in other sectors (Zhao ShiJi et al. 2012).

3 | Market-Oriented Institutional Arrangements and Agricultural Development

There are options for institutional arrangements to support agricultural development and rural transformation. When

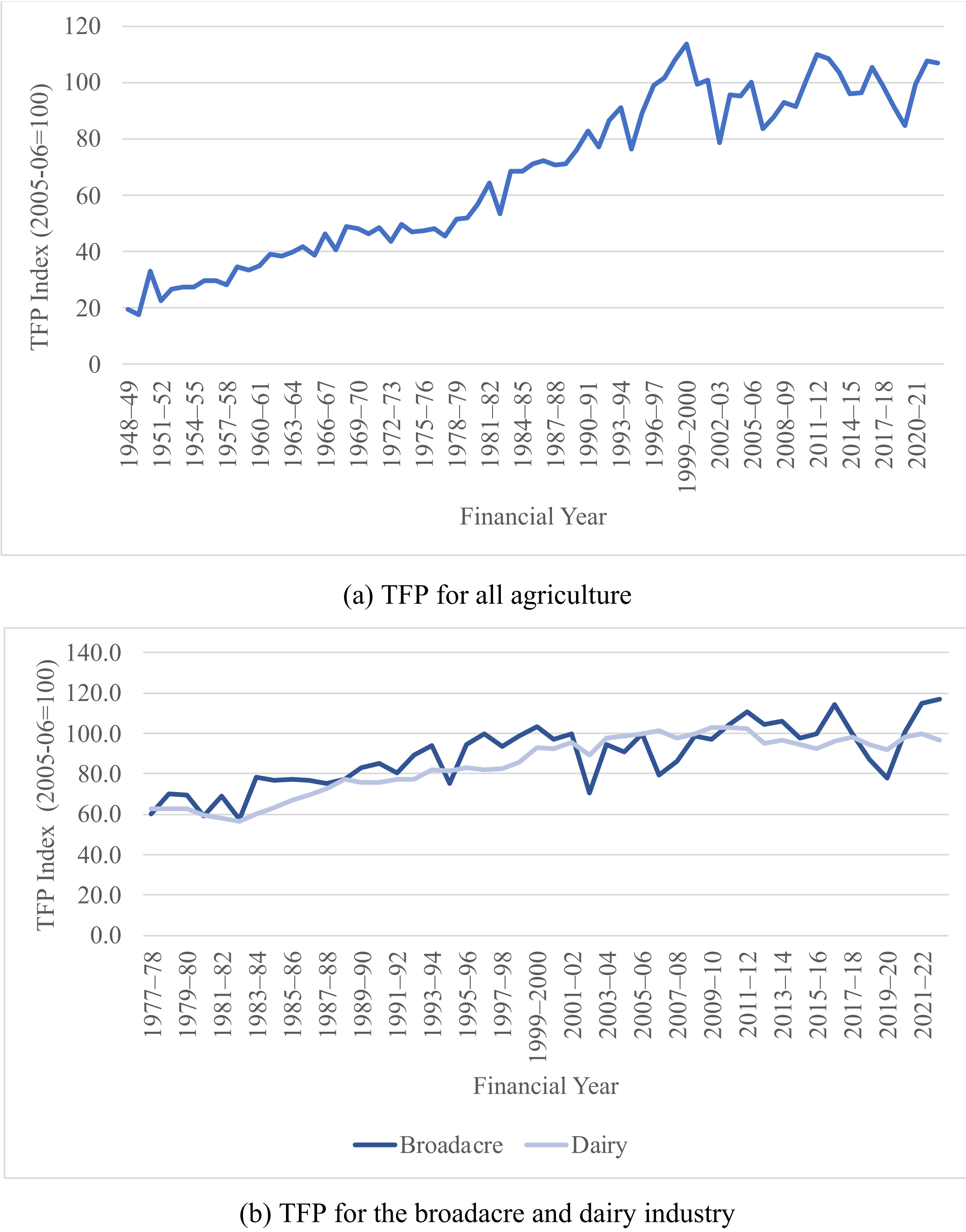


FIGURE 3 | Agricultural TFP changes in Australia. *Source:* Compiled by authors based on data from ABARES Australian Agricultural Productivity Database (2023) for year 1948–2011 and USDA-ERS International Agricultural Productivity Database (2023) for year 2012–2022.

choosing between the two major ones—market-oriented and centrally planned institutional arrangements—many countries in Asia and the Pacific region initially preferred the latter by centralising the management of agricultural production and trade. For example, China and Vietnam strictly managed agricultural trade domestically and internationally before the 1990s, in addition to implementing centrally planned land tenure systems. Other countries, such as Indonesia, Philippines, also had heavy intervention in agricultural trade and domestic markets for the same periods (International Fund for Agricultural Development (IFAD) 2020; S. Fan et al. 2024). However, centrally planned institutional arrangements were not designed for the purpose of rural transformation, nor were they conducive to it. In comparison, market-oriented institutional designs could be a better choice. In this context, the path of agricultural development in Australia over the past 70 years is relevant.

While Australia is now recognised as a market-based and open-to-trade economy, it has a long history of protectionism. Since the establishment of the federal government in 1901, trade barriers were implemented to promote domestic manufacturing activities and to provide relatively generous wages and conditions for immigrant labour. The Industrial Relations Commission set these wage and condition standards nationwide (Productivity Commission 2005a). Before World War II, direct

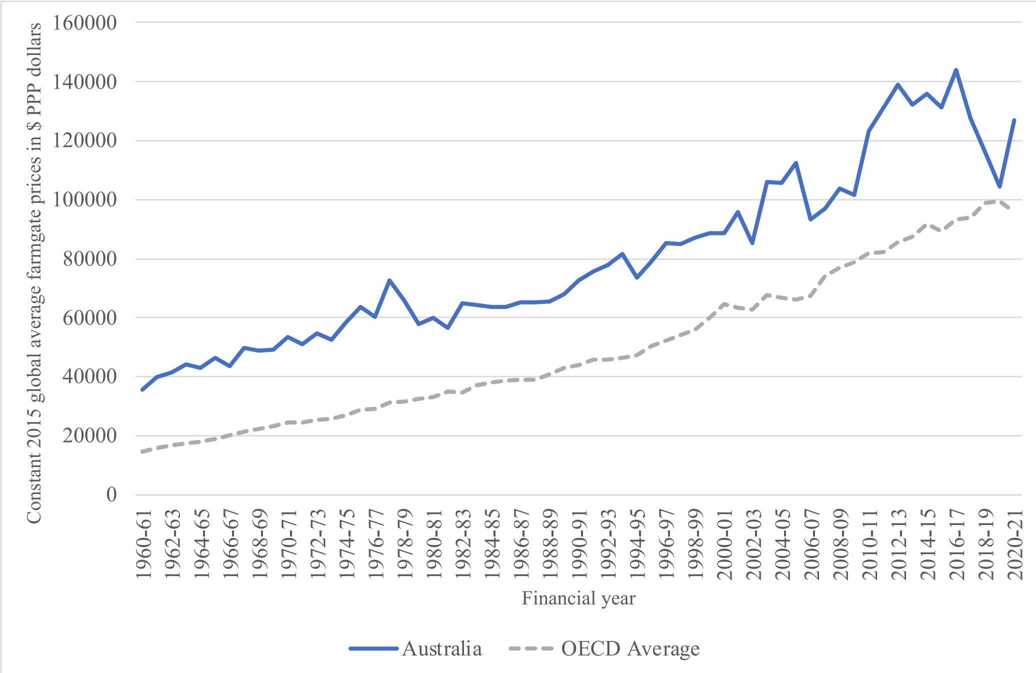


FIGURE 4 | The trends in agricultural labour income, 1960–61 to 2020–21. Agricultural labour is defined as persons economically active in agriculture, 15+ years. *Source:* Authors' estimations. The data is sourced from USDA Economic Research Service (2023).

trade protection measures were applied to agricultural sectors competing with imports, and additional assistance has also been provided. This was intended to (but did not completely) offset disincentives created by the high levels of protection for import-competing non-agricultural products since the 1920s (Anderson et al. 2007; Lloyd and MacLaren 2014). Support for agriculture was also extended to the exportable sectors via regulatory arrangements through the 1950s and the 1960s. These arrangements separated domestic and export markets, leading to higher domestic prices and pooled returns (Sieper 1982; Edwards 2006). Assistance to the agricultural sector in Australia reached a peak by the late 1960s,[4] with greater emphasis on production for export (in the context of a fixed exchange rate) relative to goals related to farmer income (Productivity Commission 2005a; Edwards 2006).

Disenchantment with Australia's interventionist policies across the economy led the government to implement deregulation reforms starting from the early 1970s. Findlay et al. (2021), along with (Anderson 2020), identify drivers of change, including a decline in economic performance and efforts to capture benefits from the complementarity with the growing Asian economies. The strength of key institutions providing policy analysis mattered,[5] as did the political leadership and entrepreneurship to implement the results of the analysis. Also significant was the capacity for analysing the intersectoral effects of policy, discussed by Mauldon (2021) and Anderson (2020). Another development was more active participation in the WTO, Australia having been hurt by agricultural protectionism in the rest of the world (Anderson 2020). The domestic politics of reform also changed, with a process of ad hoc policy making in consultation with interest groups replaced by the expectation of attention to national interests (Botterill 2005). This shift in institutional arrangements towards the market-based system was also associated with the formation of a new farmer organisation that worked within this framework, 'expressing a preference for the normal operation of market forces with measures to assist farmers in managing income instability' (Botterill 2005, 216).[6]

Deregulation commenced with the significant reduction of the 25% across-the-board tariff introduced in 1973, though subsequently there was some backsliding. Then, from the early 1980s, more deregulation policies were introduced. For instance, reforms to border protection arrangements were accelerated following the election of a new government in 1983. These reforms continued into the 1990s, with pressure for change driven by the continuing sluggishness of the Australian economy, which became increasingly apparent. By 1996, almost all tariffs (except for automobiles and TCF, which were on their own path to liberalisation) had fallen to 5% or less (Productivity Commission 2005b).

Reform occurred in all sectors, including agriculture. The effect is shown in Figure 5, where agriculture is benchmarked against manufacturing.[7] The policy measure used in this chart is the effective rate of assistance (ERA), which takes account not only of impacts of policy on outputs but also on inputs.[8]

Evident in Figure 5 is the fall in assistance to agriculture, at first a significant fall until the mid-1970s and then another round of reductions in the early 1990s. At the same time, assistance to manufacturing also fell, but a bias against agriculture remained. There was zero output tariff assistance to agriculture, but it faced a penalty from tariffs on its inputs. Lloyd and MacLaren (2014) observe that this bias against agriculture was especially strong for the exportable items—wool, meat, and wheat. However, as manufacturing tariffs fell, the size of that penalty also fell (Productivity Commission, 2023a, 2023b, Figure 1.2). In recent years, the ERA for agriculture has exceeded that for manufacturing.[9]

Figure 6 shows patterns of assistance across various agricultural sectors. These data, from the AgIncentives database, divide support into three categories: crops, livestock, and 'unallocated'. The last of these accounts for the bulk of assistance, since total assistance in the figure is of the order of 4%–5% (RH axis) but that measured at the product level is less than 0.5%.[10] Of interest is the doubling of unallocated assistance since 2016, to return the level at the start of the time series. This is mainly due to increases in 'payments based on input use'.

This level of support remains relatively low. Across 2020–22, OECD countries' producer support was over 15% of gross farm receipts (Organisation for Eco and nomic Co-operation and Development (OECD) 2023). The number for Australia in the same period was just over 4%. The extent of support which is potentially distorting of output decisions is also less in Australia. General services support accounts for over half of the total, and its share has been steadily rising since the mid-1980s. This includes support for research and development and infrastructure, including for water (Greenville 2020). The substantial reduction in market intervention and protection coincides with rapid agricultural output growth and output structural change.

While the establishment of Australian Reserve Price Scheme in the early 1970s is an exception, there is a consensus that the collapse of the Scheme in 1991 significantly reshaped the agricultural output structure, reducing the share of wool and animal skins in total production. Introduced in 1974 to stabilise wool prices by guaranteeing producers a minimum price through buffer stock purchases, the scheme led to unsustainable

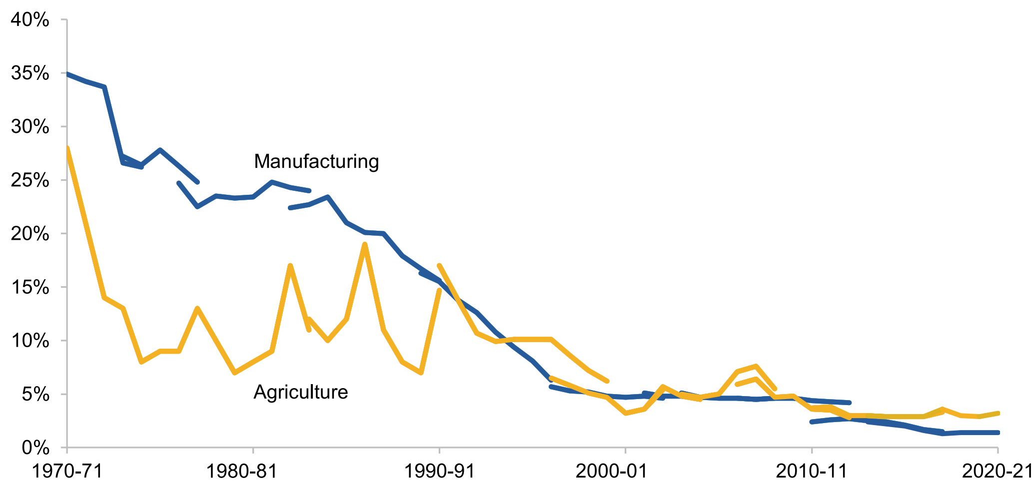


FIGURE 5 | Effective rates of assistance, agriculture and manufacturing, Australia, 1970–71 to 2020–21. *Source:* Productivity Commission, 2023, Figure 1.1.

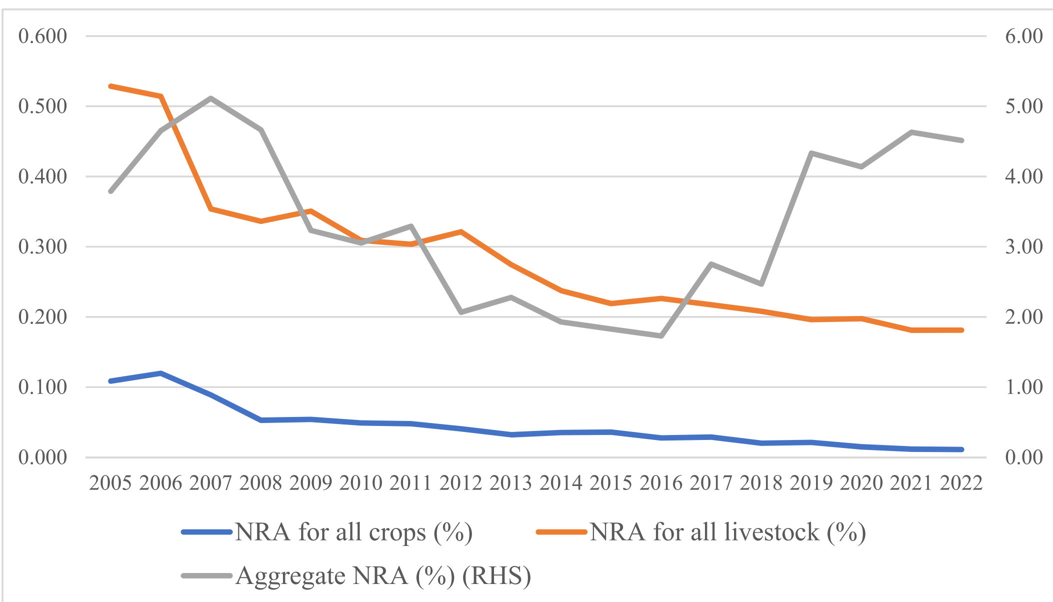


FIGURE 6 | Patterns of assistance, Australia, 2005–2022 (% of the value of output). *Source:* AgIncentives data base (https://www.agincentives.org/).

stockpiles amid a global oversupply and rising use of synthetic fibres. Australian wool production peaked in 1989–90 at 1050 million kilogrammes with 170 million sheep, but the scheme's collapse triggered a price plunge to $3 per kilogramme in 1992–93 (approximately $6/kg in 2021–22 terms). This, coupled with the Millennium drought (1997–2010), reduced sheep numbers from 120 million in 1997 to 68 million by 2010 (ABARES data). Deregulation and marketisation reforms in the 1980s and 1990s, including the scheme's termination, drove resource reallocation towards cropping and other livestock industries, which exhibited higher TFP growth (Productivity Commission 1999). These reforms fostered innovation and efficiency, increasing cropping's output value share from 35% in 1980 to over 50% by 2000. While the collapse initially disrupted rural economies, particularly in Western Australia, TFP-driven adjustments enhanced agricultural resilience and diversification, aligning with global market dynamics.

We make two comments about this evolution of institutional arrangements towards greater use of markets. The first is about the capacity to undertake reform, and the drivers of which we noted above. Anderson et al. (2007) stress, in a discussion of lessons for other economies, that market-oriented reform in Australia was possible in the 1970s because the whole economy was facing a large and long-standing distortion of domestic compared to international prices by then. They also note that (1) the market-oriented reform in agriculture is facilitated when assistance to other sectors of the economy is reduced at the same time, (2) reductions in assistance are easier to implement since adjustment is facilitated when there is greater heterogeneity between sectors and between firms within sectors, and (3) the scope and quality of the institutions of policy making and analysis are essential to success.

The second comment on this experience is about the consequences of reform. The market-oriented deregulation reforms in the 1970s made significant contributions to agricultural productivity growth. On one hand, deregulation and the elimination of trade barriers paved the way for the adoption of new technologies by reducing credit constraints, strengthening incentives, and the capacity of farms to innovate, consequently enhancing the overall efficiency improvement of farm sectors through intensifying the market competition and resource reallocation (O'Donnell 2008; O'Donnell 2010; Hughes et al. 2011). On the other hand, the relaxation of market intervention and price support in domestic markets encouraged the commercialisation of the agricultural sector. This, in turn, led to farm consolidation, improved risk management, and changes in the mix of agricultural commodities produced. These changes reallocated resources from less efficient to more efficient farms, enabling more efficient producers to gain a greater market share over time (Andrews and Cingano 2014; Sheng et al. 2020).

Using the broadacre industry as a case study, Sheng et al. (2020) examined the impact of deregulation reforms on aggregate agricultural total factor productivity (TFP) through technological progress and resource reallocation. Their study highlights that the structural adjustments in farm resource use efficiency resulting from deregulation played a crucial role in enabling Australia to maintain productivity and competitiveness against major competitors during the 1980s (see Figure 7). This finding is supported by other research, such as that of the Productivity Commission (2005b) for the overall agricultural sector and Sheng et al. (2020) for the dairy industry. Australia experienced a remarkable surge in TFP in agriculture during the 1990s, with an average growth rate of nearly 3.5%. This growth outpaced that of other developed countries such as Canada and the United States by approximately 2% and exceeded the average TFP growth of OECD countries during the same period (OECD 2015, 2019).

4 | Agricultural R&D Policies, TFP Growth and Rural Transformation

Rural transformation depends on technological progress leading to agricultural TFP growth. Public R&D policy is the relevant IPI. In Australia, an ongoing adjustment in agricultural R&D policies, along with other institutional reforms and investments, has supported rural transformation over the post-war period.

Like other OECD countries, the public sector in Australia has dominated agricultural R&D investment. Starting from the late

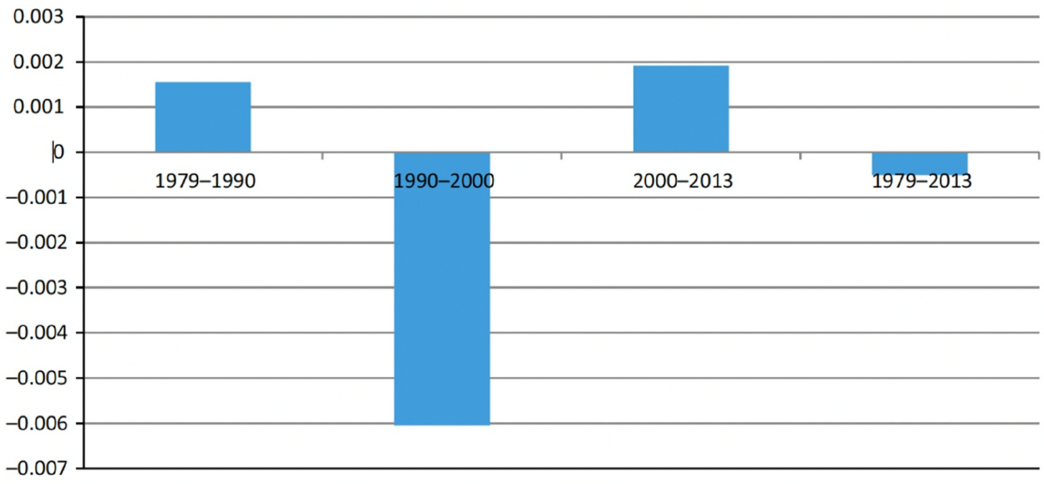


FIGURE 7 | Contribution of resource reallocation to industry-level TFP growth, 1979 to 2013. *Source:* Sheng et al. (2020).

19th century, Department of Agriculture, Forestry and Fishery (DAFF) started to fund the establishment of research institutions, such as Roseworthy Agricultural College (1883), and agricultural schools at University of Sydney (1910) and University of Melbourne (1910) (Hogan and Young 2015). During the first half of the 20th century, many agricultural experiment stations were further established across states with the support of states and territory governments. In 1926, Australian federal government directly established the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to undertake rural R&D activities. With the establishment of CSIRO, the Commonwealth Government became directly involved in Australian rural research, and CSIRO has since become an important provider of rural R&D in Australia. In addition to sponsoring the establishment of research institutes, both the federal and state governments have also made a large amount of direct investment in agricultural R&D activities. By the late 1970s, the public sector's share of agricultural R&D funding had accounted for more than 90% of total agricultural R&D (Mullen 2010).

However, the total amount of public investment in agricultural R&D started to stagnate in the late 1970s due to increasing budget constraints faced by both federal and state governments (as shown in Figure 8). According to Sheng et al. (2011), the annual growth rate of public R&D expenditure for agriculture decreased from approximately 7% per year between 1952–53 and 1977–78 to about 0.6% per year from 1977–78 to 2006–07. Although there was a short-term increase in the 2010s, it was followed by an immediate sharp decline in the 2020s. This stagnation in public investment since the late 1970s raised concerns about the future sustainability and competitiveness of Australia's agricultural sector.

To cope with these concerns and fix the declining trend of public R&D investment, a set of reforms were made to the agricultural R&D system with the aim of introducing a private-public partnership jointly supporting agricultural R&D investment. In 1988–89, the Australian government created a set of rural research and development corporations (RDC) to provide an industry-driven, market-responsive mechanism that incentivises farmers to collectively fund R&D (Zhou 2013). This was later called the RDC reform. 'The attractiveness and uniqueness of the RDC system lie in its ability to address market failures in the provision of research by ameliorating the non-exclusive character of the information generated by the research while retaining its non-rival benefits, thus ensuring that public funds are not spent on research of little practical value and facilitating greater and faster uptake of research outputs' (Productivity Commission, 2011). The RDC system, in nature, is a co-investment funded by the industry (a levy on producers) and the Australian government, with a government match capped at 0.5% of GVP (Australian Government, 2022).

The Australian Productivity Commission's 2011 report on Rural Research and Development Corporations (RDCs) evaluated the co-investment model between rural industries and the Australian Government and showed that the implementation of the system has contributed approximately AUD $490 million annually to rural R&D between 1988–89 and 2008–09. Specifically, the co-investment approach helped represent both public and private interests. The RDCs have successfully facilitated significant benefits in productivity and sustainability for rural industries. However, the weaknesses of the RDC model were also identified, such as a lack of comprehensive data on overall rural R&D funding and spending, hindering effective evaluation and decision-making. Additionally, the existing framework did not adequately attend to research topics beyond industry-specific projects.

The debate surrounding this funding model also touched on the balance of contributions between farmers and the government. As noted, the existing structure involved government matching contributions up to 0.5% of an industry's gross value of production (GVP). In its 2011 report, the Commission recommended reducing this cap to 0.25% over a 10-year period. To

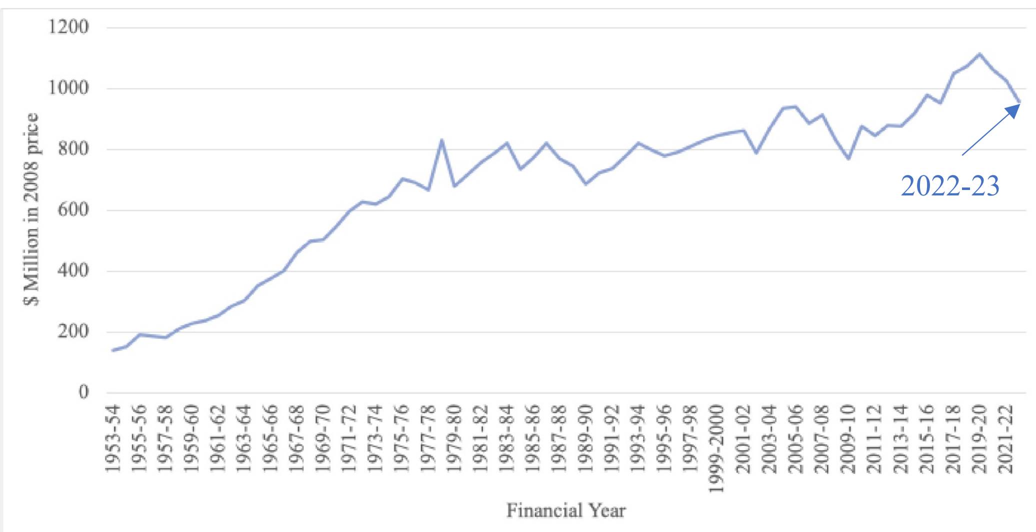


FIGURE 8 | The trend in agricultural public R&D expenditure in Australia's broadacre, 1953–54 to 2022–23. *Source:* The data for 1953 to 2007 is sourced from Sheng et al. (2011), and for 2008–2023 is sourced from ABARES (2025).

encourage increased industry investment, the Commission further proposed a new uncapped subsidy of 20 cents per dollar for industry contributions above the matching cap.

However, the Australian Government rejected the proposal to halve the cap on government matching contributions, as it did not want to reduce overall funding for rural R&D. Industry representatives had mixed reactions: some were concerned that changes to the funding model might reduce the focus on industry-specific research, while others supported proposals for better data collection and more transparent funding mechanisms. In response to the Productivity Commission's report, the Australian Government released the 2012 Rural Research and Development Policy Statement. This policy maintained the current cap on matching contributions and supported the development of Rural Research Australia to focus on broader rural R&D topics.

This approach aligns with the broader challenge identified by Howard Partners (2018), who argue that future policy must shift focus towards actively fostering a more integrated innovation ecosystem. This includes ensuring that funding and institutional frameworks incentivise genuine partnerships and enhance the translation of research findings into tangible commercial outcomes and widespread industry application.

The extension of agricultural innovation in Australia has also changed, becoming increasingly privatised over time. More private firms have emerged, investing in the development of high-yield seeds, high-quality chemicals, and improved farming practices. As the number of farms decreases, average farm sizes increased, and thus large farms gradually played a relatively more important role in distributing newly developed knowledge. Currently, the extension of agricultural innovations is largely dominated by the private sector, especially the RDC system is considered to operate under a private mechanism (Gray et al. 2012). For example, an estimated $316 million was invested in extension activities in 2014–15, with nearly half of that funding coming from the private sector (farm advisors) (Millist et al. 2017). More recently, the private sector has even overtaken the public sector as the main funder of agricultural R&D, investing $1.52 billion (2024 prices) compared to the public sector's $1.47 billion (2024 prices) in 2023–24 (Chancellor 2023; ABARES 2025).

However, the public R&D and extension expenditure, though declined over time, has continued to play an important role in improving the efficiency of agricultural production. Empirical evidence suggests that the internal rate of return (IRR) to agricultural R&D investment in Australia remains high, significantly contributing to the country's commendable agricultural productivity growth (Mullen and Cox 1995; Sheng et al. 2011). Public investment in R&D has yielded substantial returns, with IRRs estimated to range between 15.4% and 38.2% per annum, depending on the specification used. The returns to public extension activities were even more impressive, with IRRs estimated to range from 32.6% to 57.1% per year, according to the preferred gamma model specification. While these figures highlight impressive annual returns from specific public investments, a comprehensive overview of the long-term transformation (1953–2007) shows that the estimated IRRs of the aggregation of public, private, and extension investments ranged from 10.8% to 18.5% (see Table 1).[11]

TABLE 1 | The internal rate of returns (IRRs) to agricultural RD&E investment in Australia.

Scenario	Benefit-cost ratio	IRRs
Productivity growth at 1.6%		
(a) Public research only		
R&D from 1918 to 2007	15.1	16.80%
R&D from 1953 to 2007	18.5	
(b) Public + private research + extension		
R&D from 1918 to 2007	10.8	15.60%
R&D from 1953 to 2007	13.2	
Productivity growth at 1.0%		
(a) Public research only		
R&D from 1918 to 2007	8.5	14.50%
R&D from 1953 to 2007	10.3	
(b) Public + private research + extension		
R&D from 1918 to 2007	6.2	13.30%
R&D from 1953 to 2007	7.7	

Note: In the scenario with productivity growth at 1.6%, gains are from both domestic and foreign sources. In the scenario with productivity growth at 1.0%, gains are solely from domestic source.
Source: Mullen (2010).

Driven by the declining public R&D investment, agricultural TFP growth, once marked by a steady upward trend, has slowed over the past 2 decades (Alston et al. 2010; Sheng et al. 2011). Other studies also attribute this deceleration to climate-related challenges such as more frequent droughts and floods, as well as demographic shifts, including an ageing rural workforce (Sheng et al. 2010; Hughes et al. 2019). Regardless of the underlying debate, it is evident that public R&D and extension knowledge stocks grew by an impressive 5.8% per year historically, contributing over half of the annual TFP growth in Australia's broadacre agriculture from 1952–53 to 2006–07 (Sheng et al. 2011). The international spill-ins from the agricultural R&D investment overseas, such as the foreign investment in GM technology and new chemical inputs, also plays a significant role, as multinational companies' business models support the increased international movement of innovations in the food and agricultural sectors. However, as noted by Alston and Pardey (2014), the cross-country flow of these technologies can be limited by regulatory restrictions, lack of effective intellectual property protection, and the fragmented nature of farms in many recipient countries. This highlights the critical role of public R&D investment in driving productivity growth and supporting the structural transformation of Australia's rural sector.

5 | Water Market, Irrigation Reform and Public Infrastructure

Australia is characterised by an arid climate: approximately 80% of the continent receives a median annual rainfall of less than 600 mm, and 50% experiences less than 300 mm. Australia also exhibits a wide range of mean annual temperatures. Most of mainland Australia receives over 3000 h of sunshine annually. Moreover, the recent global warming, combined with extreme weather events like the Millennium Drought (2000–01 to 2008–09) (see Figure 9), further reduces water supply to agricultural production across much of the continent (Bark et al. 2014).

Some farmers in response to limited rainfall rely on irrigation water, fed by the major river systems. In 2019–20, there were 1.9 million hectares of farmland irrigated which accounted for around 0.5% of total arable land. The Murray-Darling Basin is particularly significant, accounting for 60% of all irrigated land in Australia (Australian Bureau of Statistics. ABS 2024). Within this basin, pasture and cereal crops for grazing represented the most irrigated agricultural products in 2020–21, followed by cereal crops and cotton (see Figure 10). Concerns persist over the overallocation of water resources and environmental degradation, following the impacts of the Millennium Drought, leading to questions about the balance in water-sharing arrangements between environmental needs and irrigation (Bark et al. 2014).

To increase the efficiency of the collection and use of irrigation water in agriculture, the Australian Government initiated a series of water reforms since 1994 when the Council of Australian Governments (COAG)[12] water reform framework started. Thereafter, the national water initiative (NWI) was agreed upon in 2004. Added later were initiatives such as the Living Murray Programme and the National Plan for Water Security in 2007, 'Restoring the Balance' programme in 2008, and the Sustainable Rural Water Use and Infrastructure Programme in 2009 (Productivity Commission 2009). Later stages of reform also involved the establishment of the Murray-Darling Basin Plan (MDB Plan) in 2012, later enshrined in the Water Act (Australian Government 2014). These reforms aimed to define annual water allocations from the basin and establish a framework to balance environmental preservation with agricultural irrigation.

The Living Murray programme was an AUD $1 billion initiative, first introduced in 2001–02 and then continued to operate alongside other water management programs. It was designed to recover 500 GL of water for significant environmental sites in the southern MDB. This programme-initiated investments in MDB irrigation infrastructure to improve economic, social, and environmental values. The Water Act in 2011–12 was designed to prioritise market-based approaches for recovering environmental water by purchasing water rights. Concurrently, the Commonwealth Environmental Water Office was established to manage these water rights for environmental benefits (Loch and Adamson 2015).

Under these reform frameworks, water resources within the Murray-Darling region were reallocated through various strategies, including market-based initiatives for environmental water recovery, investments in irrigation infrastructure, and regulatory measures to benefit irrigated communities (Crase et al. 2012). In a recent study, S. Wheeler et al. (2023) found that the agricultural economic values of the water in the MDB remain significant but are decreasing due to water recovery programs and climate change, while community economic and recreational values are increasing.

Apart from establishing institutions for groundwater management, Australian government have also started to emphasise the importance of strengthening infrastructure investments in recent years. An example is that the Sustainable Rural Water Use and Infrastructure Programme (SRWUIP) was initiated in 2009 with the lump-sum fund of AUD $5.9 billion (Treasury, 2009).

The establishment of water markets and infrastructure development under these reforms has significantly influenced agricultural production. Water markets enhance economic efficiency in the agricultural sector (Qureshi et al. 2009). Studies have estimated substantial economic benefits; for instance, Peterson et al. (2004) estimated gains of AUD $495 million from water trade in a dry year, while the National Water Commission (2010) suggested that water trading increased Australia's GDP by AUD $220 million in 2008–09. Jiang and Grafton (2012) found that water trading could mitigate on-farm impacts of climate change and reduce surface water availability. Furthermore, water trading reforms have generated additional benefits at both the farm and economy levels. S. A. Wheeler et al. (2014) and S. Wheeler et al. (2014) demonstrated that water trading could improve farms' cash flow during drought periods, thereby reducing farm debt and supporting local economies. S. Wheeler et al. (2016) examined the effects of water market reforms in the MDB and concluded that, when effectively implemented, water markets could enhance environmental outcomes, assist irrigators in adapting to climate risks, and increase the gross value added of farming. Seidl et al. (2020) analysed water markets as analogous to stock markets, suggesting that water market reforms should adopt financial market practices to improve transparency and manage price volatility. S. A. Wheeler (2022) found that water markets have demonstrated allocative, dynamic, and productive efficiency benefits.

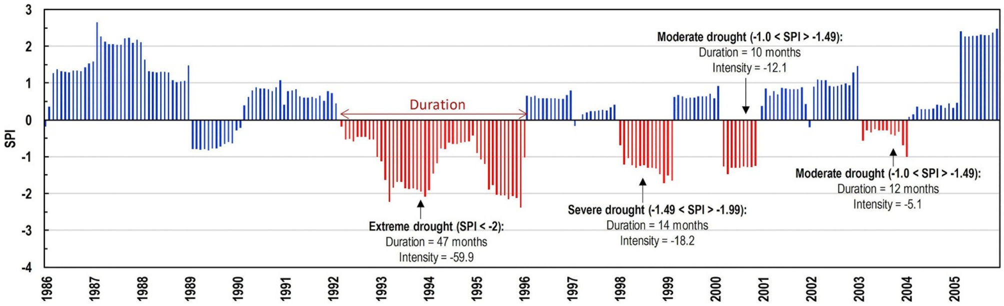
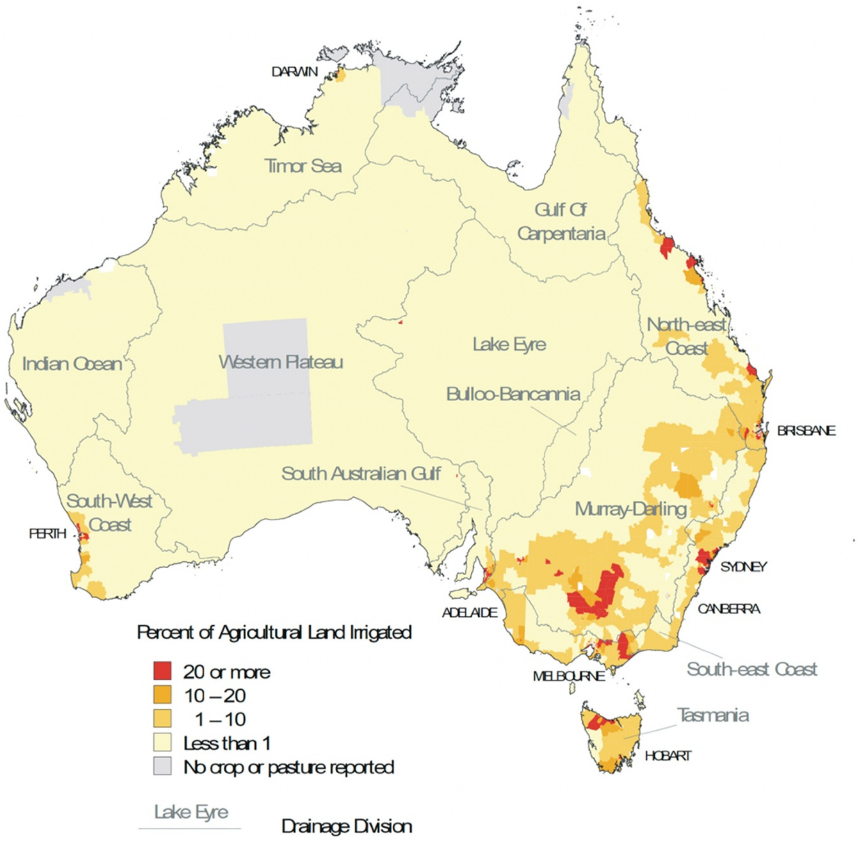
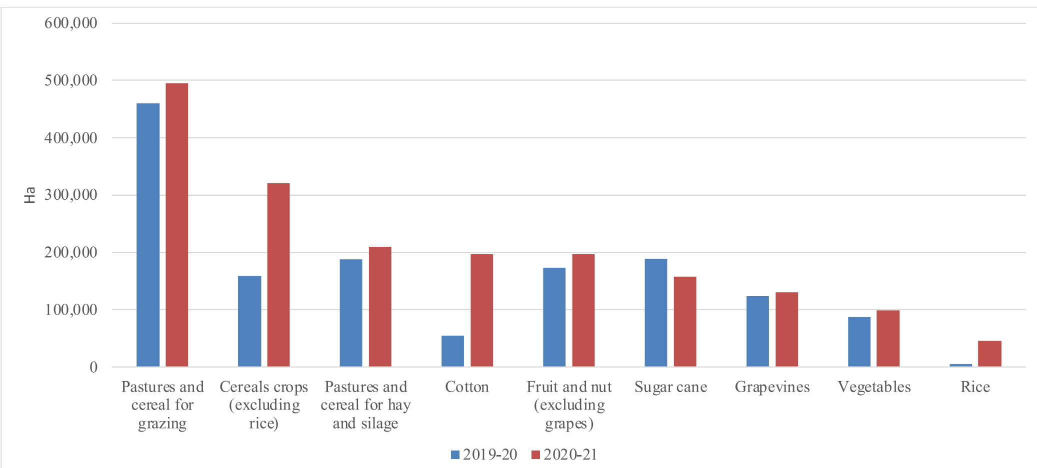


FIGURE 9 | Drought events in Australia, 1986 to 2005. The drought events are characterised by the Standardised Precipitation Index (SPI; McKee et al. 1993). *Source:* Kirono et al. (2020).



(a) Irrigated areas



(b) Irrigated agricultural land changes for selected crops and pastures within the Murray Darling Basin, 2019-2020 to 2020-21

FIGURE 10 | Agricultural irrigation conditions in Australia. Pastures and cereal for grazing includes both lucerne pastures and areas of cereal crops fed off; Pastures and cereal for hay and silage includes lucerne pastures cut for hay and silage. *Source:* The geographical distribution of irrigated areas is sourced from Meyer (2005); The changes in irrigated agricultural land for selected commodities are sourced from the Australian Bureau of Statistics, 'Water Use on Australian Farms,' (2024).

Investments in infrastructure significantly add to the profitability of the irrigated agricultural sector. Modernising irrigation infrastructure directly improves efficiency, leading to water savings that can be used to irrigate additional land or enhance productivity on existing areas (Koech and Langat 2018). This positive impact has been evident in Australia's irrigated sector: for example, between 1996–97 and 2000–01, the estimated revenue generated by irrigated agricultural production in the

Murray-Darling Basin increased by 50%, largely due to the expansion of horticultural production (Meyer 2005). More broadly, since 1985, improved irrigation technology and infrastructure have supported a 30% increase in the total irrigated area in Australia, alongside a 75% increase in water diverted to sustain this expansion (Meyer 2006).

The rollout of the Murray-Darling Basin (MDB) Plan has further facilitated the modernisation of irrigation infrastructure, driving significant management and technical changes in agricultural production. These changes have directly benefited farmers through increased crop yields and labour cost savings (Loch and Adamson 2015; Department of Agriculture and Water Resources (DAWR) 2019). The positive impact is particularly evident in the cotton industry: while irrigated cotton crops typically utilize 6–7 ML/ha of water annually, they have achieved substantial improvements in efficiency. Over 2000s, water-use productivity by Australian cotton growers notably increased by 40%. The underlying drivers of these productivity and efficiency increases include advances in plant breeding, the widespread adoption of genetically modified (GM) varieties, and refined crop management practices (Roth et al. 2013).

The latest inquiry by the Productivity Commission regarding national water reform is underway in 2024. This inquiry focuses on the impact of climate change, which is rendering rainfall increasingly unreliable, amidst changing water demand. The report proposes renewing the 2004 National Water Initiative and recommends strengthening national cooperation in water management, enhancing knowledge sharing, and promoting best practices. It also emphasises the necessity of improving representation of First Nations peoples in water planning, incorporating their objectives into water plans, and ensuring access to water through native title rights.

The report gives attention to the problems of overallocated and overused water systems and of integrating surface water and groundwater management. The Commission recommends removing unwarranted trade barriers in water markets, enhancing market transparency, and establishing a central clearinghouse to manage price volatility. Furthermore, the report makes the case for best practice pricing and regulation, ensuring cost recovery for water planning and management activities, and addressing the environmental externalities of water use.

The success of water market reform in facilitating agricultural development also depends on a well-designed institutional framework. S. A. Wheeler et al. (2024) focus on establishing a robust framework to assess the quality of economic studies related to water resources. This framework aims to provide a systematic method for evaluating the quality of water economic studies, addressing variability in study quality to ensure that policy decisions are informed by reliable research. Drawing inspiration from health research, which employs grading systems to ensure robustness in findings, the framework highlights the necessity for higher standards in economic studies that inform policymaking. Utilizing high-quality studies can lead to more balanced policy decisions, thereby mitigating the risks of overestimating negative impacts and providing clearer insights into complex market dynamics.

One such complex and often debated dynamic concerns the role of non-user participants. Zhao et al. (2024) discuss the role of these non-land-holding investors in the southern Murray-Darling Basin's (sMDB) water market. Their involvement has intensified water trading activities, contributing to the 'financialization' of water, where the market increasingly resembles other financial markets with sophisticated investment management and derivative products like forward contracts and entitlement leasing. A significant aspect of the ongoing debate, however, revolves around the perceived impact of these non-user speculators. There are acknowledged concerns and suspicions among some stakeholders that their speculative activities might be driving up water entitlement and allocation prices, potentially to the detriment of agricultural water users. Nevertheless, the study also highlights counter-evidence from the Australian Competition and Consumer Commission (ACCC), which investigated these concerns but found no conclusive evidence of market power or manipulation by financial investors causing distortion.

Beyond the ongoing market reform and debates surrounding agricultural water allocation, a more complex and concerning issue involves the efficiency and effectiveness of environmental water use. Specifically, the ecological outcomes achieved per unit of water have not received the same level of rigorous study as agricultural water use efficiency. Most research in this area remains qualitative, often focused on policy frameworks, and is further constrained by the inherent complexity of ecological systems. Given these limitations, there is significant value in building more robust indicators, developing better modelling approaches, and undertaking further empirical studies to assess and ultimately improve the efficiency of environmental water use in Australia.

6 | Conclusion

The Australian agricultural sector's remarkable resurgence since the 1970s serves as a testament to the transformative power of strategic policy reforms and a commitment to innovation. This paper has provided an analysis of Australia's agricultural policy evolution, with a focus on the pivotal impact of deregulation reform, changing in agricultural R&D system, and targeted investments in irrigation system, on rural transformation.

The deregulation reforms that began in the 1970s have been a cornerstone of the sector's resilience and adaptability, fostering an environment conducive to innovation and efficiency. These reforms have significantly contributed to the sector's productivity growth, with agricultural TFP growing at an impressive annual rate of 1.4%, accounting for more than two-thirds of the annual agricultural output growth rate of 2.4% (Sheng et al. 2010).

Investment in agricultural R&D has been fundamental in agricultural development and rural transformation, driving not only agricultural productivity growth but also sustainable practices that align with global environmental and health standards. Public investment in R&D has yielded substantial returns, with internal rates of return (IRRs) estimated to range between 15.4% and 38.2% per annum, depending on the model specification used (Mullen 2007, 2010; Sheng et al. 2011).

The irrigation policy and water management reforms, particularly within the Murray-Darling Basin, highlights the intricate balance between resource utilization and environmental stewardship. The water reforms initiated in 1993–94, including the Murray-Darling Basin Plan, have been pivotal in defining annual water allocation, introducing market-based initiatives for efficient water recovery, and investing in irrigation infrastructure to conserve water (Crase et al. 2012).

In conclusion, Australia's journey in agricultural policy reform serves as a compelling case study for other nations. As the global agricultural sector navigates the complexities of climate change, technological advancements, and evolving market demands, the lessons drawn from Australia's experience are both relevant and timely. It demonstrates the efficacy of a market-oriented approach, the significance of sustained RD&E investments, and the necessity for adaptive and forward-thinking policies in water management. As the sector continues to evolve, Australia's strategic approach provides a blueprint for achieving rural transformation and agricultural excellence on a global scale.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

[1] Due to our specific focus on the direct impact of Institutions, Policies, and Investments (IPIs) on the structural transformation of agricultural output and employment within Australia's unique historical context, we concentrate on on-farm production.

[2] These productivity estimates, derived from the annual Australian Agricultural and Grazing Industries Survey (AAGIS) and the Australian Dairy Industry Survey (ADIS), represent data from approximately 1600 broadacre and 300 dairy farms. Farms are weighted to ensure representativeness across regional, state, and national levels. ABARES employs a conventional growth accounting approach, consistent with the OECD Manual and ABS methods, to estimate productivity. This unique approach leverages AAGIS and ADIS data to provide aggregate productivity statistics at national, industry, and regional levels, as well as for individual farms. It also enables sophisticated 'climate-adjusted' productivity estimates and detailed econometric analysis for policy insights. The estimation follows a three-step process: constructing capital, output, and other input variables (labour, land, materials, services); aggregating total output and input using price weights; and finally, generating the productivity index by dividing the total output index by the total input index.

[3] In comparison, the manufacturing and service sectors employed 12.3% and 70.2% of the workforce, respectively, and contributed 11.9% and 64.3% to the GDP, respectively in 2023–24.

[4] Anderson et al. (2007) point out that the variation in assistance was increasing, which indicated increasing levels of resource misallocation within agriculture.

[5] Botterill (2005) discusses the roles of the Bureau of Agricultural Economics (and its widening role in policy analysis) and of the Industries Assistance Commission (which provided policy advice publicly and independently), as well as an important national and independent review of agricultural policy (the Rural Policy Green Paper of May 1974).

[6] With respect to matters related to income instability, in 1977, the government introduced the Income Equalisation Deposits Scheme, operating through the reform on the taxation system, alongside carry-on loans and household support (Zhou 2013). These schemes were also linked to assistance for farmers experiencing droughts.

[7] Lloyd and MacLaren (2014) review nominal rates of assistance to agriculture since 1900 up to 2009, which they divide into importable, exportable and all commodities. Anderson et al. (2007) undertake the same analysis for the period 1946 to 2004. Both show the rapid rise in assistance to all categories after World War II, leading to a peak in the early 1970s, the date at which Figure 5 begins. See also Anderson (2020).

[8] Chapter 1 of Productivity Commission (2023a, 2023b) provides more information on the calculation of effective rates of assistance. Breaks and overlaps in Figure 5 refer to changes in methodology or data sources.

[9] There are high levels of budgetary assistance to the services sectors, which account for 50 percent of the total (which is less than the sector's share of the economy). However, the shares of budget assistance relative to shares of output are higher for both manufacturing and agriculture (Productivity Commission 2024).

[10] The measure of assistance here includes 'subsidies linked to production, to inputs, or to other characteristics such as current or historical land use'. https://www.agincentives.org/files/2024/05/Intro_to_AgIncentives_2024_04_30.pdf.

[11] The methodology used by Alston et al. (2010), Mullen and Cox (1995), and Sheng et al. (2011) constructs knowledge stocks to proxy accumulated public R&D and extension efforts using lagged investment data weighted by distribution functions (e.g., gamma, geometric). These functions account for delays between investment and productivity impact. The knowledge stocks are then included in a regression model explaining agricultural productivity, alongside control variables such as education and seasonal conditions. Estimated elasticities from the model are used to calculate internal rates of return (IRRs).

[12] COAG was a intergovernmental forum (federal and state and territory governments) established in 1992, and operated until replaced by the National Cabinet in 2020.

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