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AUSTRALIAN AGRICULTURE: A SUSTAINABILITY STORY*

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Introduction

All economic activity is based ultimately on resources found in nature. Yet there is a pervasive and persistent view that 'economic' calculations and ways of thinking are in conflict with environmental concerns. The debate on sustainable development is the third major wave of international concern with natural resource policy since World War II, and the fifth since Malthus (1798). The first postwar wave of concern, in the late 1940s and early 1950s, focussed primarily on the adequacy of non-renewable and renewable natural resources to sustain economic growth. In Australia, there was at this time concern about the capacity of our agricultural sector to sustain a growing population. In the United States, the President's Materials Policy Commission concluded in 1952 that '. . . the supplies of the evident, the cheap, the accessible are running out'. Vernon Ruttan responded, in his 1971 Presidential Address to the American Agricultural Economics Association, stating that if the Materials Policy Commission had been writing at that time 'it would have to conclude that there have been abundant examples of the non-evident becoming evident; the expensive, cheap; and the inaccessible, accessible' (p. 708).

The lesson to be learned from the above predictions, taken together with statements made by the Club-of-Rome (The Limits to Growth, 1972) and during the 'energy crisis', is that physical indicators of the supply of productive agricultural land and estimated reserves of energy and mineral resources, are by themselves inadequate and misleading measures of resource scarcity. For those natural resources for which markets exist, it is now widely accepted that the price system is the most effective indicator we have of both absolute and relative resource scarcity.

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Following the issue of the adequacy of the natural resource base to sustain growth, the focus of the second postwar wave of concern, beginning in the developed countries in the late 1960s, was with the stress put on the environment by economic growth. Increasing competition between the demand for environmental services for disposal of residuals and demand for environmental amenities has produced substantial rises in the economic value of common property and open-access environmental resources. Such competition is further intensified because the renewable resources providing the above environmental services may simultaneously provide physical goods for direct consumption (e.g. native timber, fish, and drinking water) and may also be used as a flow input for production (e.g. irrigation water).

From the perspective of a developing country, the debate about the environment was at that time mainly seen as a concern for luxury services that loom large in public consciousness only in high-income countries. The thinking that environmental resources play an insignificant role in the development process of poor countries is reflected in the literature on development economics. Dasgupta and Maler (1991) point out, for instance, that the two-volume *Handbook of Development Economics* (Chenery and Srinivasan eds, (1988)), has no discussion of environmental resources and their possible bearing on economic development, while Stern's (1989) survey of development economics contains only a single sentence.

The third wave of concern for the environment centred around the concept of 'sustainability', is very recent, although Sandra Batie (1989) has traced the intellectual origins of the concept of sustainable development to the emergence of the progressive conservation movement in the United States towards the end of the 19th century. The Progressive Conservationists' philosophy embodied a strong faith in science and technological progress coupled with expert resource management, and much of the orientation of today's mainstream agricultural economics and economics reflects a similar philosophy. As Batie points out, the constrained economic growth view of sustainable development embodied in the above philosophy, and adopted in my address, departs notably from those advocates of sustainable development who subscribe to a maintenance-of-the-resource viewpoint and who generally reject scientific management of natural renewable resources.

The current debate on sustainability is taking place in both developing and developed countries. There is increasing recognition of the fact that for the poor in developing countries, environmental resources are often complementary with other goods and services. Environmental problems are usually associated with renewable natural resources which are regenerative, but which may be exhausted by excessive use. The decline in firewood and the availability of reasonable quality water are examples of specific needs which are of particular concern to many poor people. The current concerns with sustainability have also been heightened by the knowledge that human activity in one country may have international or even global impacts e.g. acid rain, depletion of the ozone layer and the enhanced greenhouse effect. The sustainability debate has focussed attention on the management of economic and ecological systems. Depending upon the problem under consideration, the relevant physical-biological unit or ecosystem for decision-making, may be small and localized, regional, national, international, or global.

The idea of sustainable development was popularised in the World Commission on Environment and Development's influential report Our Common Future (1987) (Brundtland Report). The report reflects a belief that producers and consumers should take proper account of interactions between the economy and the environment and the consequences of their actions for future generations. The focus on intergenerational obligations reflects a fear that future generations could be 'poorer' than current generations when account is taken of depletion of the natural environment. In the Brundtland report it is claimed that people are currently drawing too heavily, too quickly, on the stocks of renewable and non-renewable natural resources. Pearce, Markandya and Barbier (1988) take a further step when they state explicitly:

> We can summarize the necessary conditions for sustainable development as constancy of the natural capital stock; more strictly, the requirement for non-negative changes in the stock of natural resources, such as soil and soil quality, ground and surface water and their quality, land biomass, water biomass, and the waste assimilation capacity of the receiving environments (p.6).

However, as Dasgupta and Maler (1991) point out, from an anthropocentric perspective of economic welfare, there is nothing sacrosanct about either the 'Virgin state', or the current levels of renewable or non-renewable resource stocks that we have inherited from the past. Whether or not policy should be directed at expanding, maintaining, or contracting renewable natural resource bases, or at slowing-down or speeding-up rates of extraction of non-renewable resources, depends upon many considerations. Factors influencing policy choice include the size, composition, and quality of the existing natural resource base, the regenerative capabilities of the renewable natural resources, the state of technology and substitution possibilities between natural and produced capital, and considerations of expected rates of population change and intergenerational well-being.

The plan of the paper is as follows. In section one the concepts of net national product and economic depreciation are reviewed and their links with optimal resource use and intergenerational equity are established. In section two, the record of productivity growth in Australian agriculture, in both physical and value terms, is examined in some detail. In section three, the much debated issues of land degradation in Australia and its effects on productivity are discussed. The effects of selected rural policies that have influenced land quality are analysed within a simple framework of supply and demand for land quality. In section four, an attempt is made to identify and discuss the factors causing a decline in the economic importance of Australian agriculture. In section five concluding comments are presented.

The major theme that emerges from the discussion which follows is that productivity growth over the last four decades or so has led to an impressive increase in the productive capacity of Australian agriculture. The foregone productivity attributable to land degradation appears to be very small compared with the above productivity growth. However, despite a more than doubling of farm output, and a lowering of real per unit costs of production, there has been a downward trend in the real net value of farm output. The residual return to land from agricultural production in Australia has declined. The absolute and relative scarcity of farmland in Australia has decreased.

Net National Product, Sustainability and Intergenerational Well-Being

Conceptually, the best measure that is capable of reflecting aggregate intergenerational well-being and sustainable resource-use concerns is net national product (NNP). By definition, NNP is the sum of the social value of an economy's consumption and the social value of the real changes in its stock of capital assets, including both manufactured capital and natural resource stocks. This concept corresponds with the Simons-Haig definition of the ideal income tax base and the Hicksian idea of income as the most that can be consumed in a period so that a person is no worse off at the end of it than at the beginning. If the flow of consumption and net investment in an economy is chosen which maximizes real NNP at each date, the resultant economic path will be one which maximizes the present discounted value of the flow of aggregate well-being (Weitzman, 1976). It also follows that optimal social investment criteria are intrinsically related to the correct way of measuring real NNP in that their application ensures that real NNP is maximised in each time period.

At present, when the NNP of a country is estimated, the depreciation of physical reproducible capital is deducted, but no country to my knowledge deducts depreciation (or adds appreciation) of its natural resource stocks. Depreciation of national resource stocks of only 1-3 per cent of national income would be sufficient to switch quite healthy recorded annual economic growth rates to a true measure of zero economic growth. A striking result is that the NNP of a country that lives solely off its non-renewable resources is zero unless new resource stocks are being discovered.

The distinction between capital and income and the idea of maintaining intact indefinitely an appropriately defined capital stock underpins mainstream economic thinking about sustainability issues. Solow (1974) showed that aggregate consumption/utility could be maintained indefinitely, despite the essential use of a non-renewable resource in production. Hartwick (1977, 1978, 1990) applied Hotelling's rule for optimum management of a non-renewable resource stock over time and derived the result that society can attain a consumption stream which is constant over time if it invests the competitive rents on its current extraction of non-renewable resources in reproducible capital.[1] The value of the aggregate capital stock remains unchanged and consumption may be regarded as the 'interest' on that stock. What has now become known as 'Hartwick's Rule' was derived on the assumptions of a constant population and zero technological progress. However, the results of the model remain intuitively appealing when these assumptions are relaxed. Importantly, the basic results can be generalized to incorporate all forms of renewable resources.

The link between optimal resource use and sustainability is captured in Solow's (1986) statement:

> The current generation does not especially owe its successors a share of this or that resource. If it owes anything, it owes generalized productive capacity or, even more generally, access to a certain standard of living or level of consumption. Whether productive capacity should be transmitted across generations in the form of mineral deposits or capital equipment or technological knowledge is more a matter of efficiency than of equity (p. 142).

There is little to go on when making decisions with very long-run consequences. Hartwick's rule and the concept of economic depreciation provide a useful rule of thumb for taking account of future interests that might otherwise be dominated by short-run considerations. However, the Hartwick rule is a necessary but not sufficient condition for sustainability. Sustainability will be achieved in practice only if there is sufficient substitutability between natural resources and produced capital.

[1] The Hartwick Rule, of course, does not require the owners of depletable resources necessarily to undertake the investments in produced capital themselves. All that is necessary is that the rent income increases the pool of available savings and that those savings are employed by somebody to make the additional investments in other forms of capital. It is equally true that government's rent income (e.g. from oil, gas and mineral resources) need not directly be used to fund additional productive investments. However, there are many opportunities and temptations for government to use rent income in a manner that does not satisfy the Hartwick Rule. The essential criterion is that the government should not use rent income to fund any program or investment which does not generate a social rate of return which matches the returns earned on investment elsewhere, as measured by the interest rate which the government has to pay on borrowed funds. Smith (1990) states that in Australia there is little question that high oil revenues have been used in a manner that does not satisfy Hartwick's rule, namely to disguise the size of true budget deficits. In contrast, it is relevant to note that in Alberta (Canada) and Alaska (USA) special funds were established for royalties from natural gas and oil, respectively.

The core of the issue is how much and what type of productive capacity should be transmitted across generations and how risks between generations should be shared so that each succeeding generation can expect to be at least as well off as the current generation. In a technologically changing world, risk is inherent because of uncertainty about the long-run consequences of current actions. There is always a risk that part of the capital stock transferred may turn out to be quite inappropriate for the needs and wants of future generations, and conversely, that future generations may place a high value on some capital stock which was not transferred to them.

For agricultural production, the relevant resource stock is land, which produces an annual flow of productive services. However, physical changes in the quality/quantity of the land stock now need to be linked to effects on productivity taking into account any resultant changes in the pattern of land use. Economic depreciation/appreciation is now most simply defined as the period change in the discounted net present value of the flow of services provided by the land attributable to either physical changes in the land stock or to unexpected changes in product or factor prices. Some soils are essentially a non-renewable resource whilst other soils may be 'renewed', or have their agricultural productivity enhanced by such measures as drainage. Passmore and Brown (1991) argue that Australia's rangelands are a composite of both a non-renewable resource, soil, and a potentially renewable resource, pastures. Arid rangelands soils are a non-renewable resource because soil genesis occurs only on a geological time-scale. However, unlike the utilization of minerals or fossil fuels, these soils appear to have the potential to provide a flow of agricultural products with a negligible rate of decline in the soil stock.

More complex renewable resource situations can be envisaged. For instance, some renewable resources may be used as an input into production (e.g. water) and also provide assimilative capacity for the disposal of residuals that are a by-product of production. In addition there usually will be direct consumption or utility effects of pollution in addition to the deleterious effects of pollution on production. For example, salt discharge attributable to upstream use of water for irrigation in the Murray-Darling Basin lowers water quality for downstream irrigators and industrial users. In addition, salt discharge enters consumers' utility functions directly through its effects on water quality for drinking and other residential use and by lowering its recreational and amenity values. Conceptually, the measure of economic depreciation (appreciation) of the water, soil and other renewable natural resources in the Murray-Darling Basin is defined in the same manner, although empirical measurement would be difficult.

international demands for agricultural products at socially acceptable economic and environmental costs to current and future generations. Agricultural systems can be defined at various levels of spatial scale and aggregation: farm paddock, farm or food factory, rural industry, region, nation, and global. Lynam and Herdt (1989) argue that sustainability first needs to be defined at the most aggregate level before proceeding to less aggregate levels and that the sustainability of a system is not necessarily dependent on the sustainability of all its subsystems.[2]

Most Australian farmers are connected through trade to international markets, and with the notable exception of the wool industry, it has generally been assumed that Australia is a 'small country' and that farmers are 'price-takers' on world markets. That is to say, the export prices received by Australian farmers are, with the exception of wool, completely dependent upon production and consumption decisions in overseas countries. It is relevant to note that Australia is also effectively a small country with respect to the enhanced greenhouse effect (EGE). All Australians, including farmers, are essentially 'climate change-takers'.[3] Thus overseas (global) production and consumption activities, may through an EGE, directly affect the future productivity and pattern of farming systems in Australia.

Here, the focus is on the productivity and sustainability of the Australian agriculture sector as a whole, recognizing its national and international linkages. Productivity growth may be defined as an increase in output for a given quantity of inputs, deriving from a change in management techniques or technology. The method used in a recent ABARE (1990a) study is to compile an index of total output and an index of inputs, and then to calculate productivity change as the change in the ratio of the index of outputs to that of inputs.

Changes of total farm output and farm inputs are shown in Table 1. Total agricultural output has increased in each of the four decades from 1950-51. In the first two decades, the average annual growth rate of total agricultural output exceeded 3.0 per cent per year. In the latter two decades, the average annual growth rate has been a little less than 2.0 per cent. Over the whole period 1951-52 to 1989-90 the average annual growth rate of total agricultural output was around 2.5 per cent. It should be noted that the growth in total agricultural output is effectively measured at constant prices. The measure does

[2] Lynam and Herdt (1989) suggest that 'a sustainable system is one with a non-negative trend in measured output; a technology adds to system sustainability if it increases the slope of this trendline.' Dover and Talbot (1987) suggest that the appropriate measure of sustainability is total factor productivity of the crop, cropping system or farming system.

[3] Australia accounts for about one per cent of the world's greenhouse gas emissions.

not adequately account for substitution between products when relative output prices change over time.

The annual growth rates for Australian agriculture may be compared with figures for the developed and for the developing countries. For the developed countries as a whole, the average annual growth rate was a little over two per cent for the first two decades and around 1.5 per cent for the period 1971 to 1984. The developing countries as a whole have averaged around three per cent throughout the period 1951 to 1984 (Carter, 1988).

In contrast to the growth of total output, farm inputs in Australia have declined slightly over the last two decades, after growing strongly over the first two decades. As a result, productivity growth is lower than total output growth in the first two decades and higher in the latter two decades. Changes in the main categories of inputs are shown in Table 1. Estimates of productivity changes from a number of sources are presented in Table 2.

In terms of physical productive capacity (or what amounts to the same thing, namely constant price valuations) the historical production record points to an Australian agriculture that has sustained impressive growth over the last four decades. The index of total farm output increased two and a half times over the period 1951-52 to 1989-90. However, over the same period, there has been a substantial decline in farmers' terms of trade as shown in Figure 1. Figure 2 shows that over the last four decades there has been an upward trend in real total farm costs, but no significant trend in the real gross value of farm production, despite the fact that output has increased two and a half times. There has been a small downward trend in real farm costs per unit of output and a marked downward trend in the real gross value per unit of farm output (Figure 3). In contrast to the fairly strong positive

[4] Figures 1 to 4 are based upon analyses of data contained in ABARE *Commodity Statistical Bulletins*, December 1990 and 1991, and various issues of *Agricultural and Resources Quarterly*. Data contained in ABARE *Commodity Statistical Bulletins*, is assembled from information published by the Bureau of Census and Statistics in the Australian National Accounts: National Income and Expenditure (ANA). The ANA estimate of net farm income is the residual between independent estimates of the gross value of farm production and the total costs incurred by farmers. Included in the estimate of total costs is depreciation based on taxation allowances. Over most of the period 1949-50 to 1973-74 farmers were permitted to depreciate plant and equipment at accelerated rates. When permitted rates of depreciation exceed true economic rates of depreciation, the accelerated rates of depreciation will overstate costs in periods of net investment and understate them in periods of net disinvestment. Glau (1971) shows that over the period 1949-50 to 1968-69, the accelerated rates of depreciation used in the ANA are significantly above true economic depreciation. As a consequence of over-estimates of actual depreciation the ANA under-estimates net farm incomes over this period. In other words, real net farm income, over the period 1949-50 to 1973-74, is higher than shown in Figure 4. For further discussion of the impact of the cost-price squeeze on farm incomes see Jackson (1979) and Lloyd (1986).

TABLE 1
Measures of Outputs and Inputs for Australian Agriculture

	1951-51	1961-62	1971-72	1981-82	1989-90
Farm Output (a)	39	55	74	82	100
Annual Growth Rate of Output (per cent)		(3.5)	(3.0)	(1.1)	(2.5)
Farm Inputs					
Total Rural Labour	122	114	104	98	100
Total Capital Stock	45	63	98	107	100
Cash Inputs: (b) Volume of fertilizers, fuels, repairs, etc.		(8)	(21)	(41)	(100)
Area of farms	94	101	106	104	100
Sown area (c)		(40)	(67)	(88)	(100)
Index of total farm inputs (approx.)(d)	—	—	101	99	98
Ratio of prices received to prices paid	100	69	60	44	39

(a) Farm output and other (unbracketed) figures are for three year averages centred on each year. Unless otherwise stated, the source of the basic data from which estimates are derived is ABARE *Commodity Statistical Bulletin*, December 1990, AGPS, Canberra.
(b) and (c) Sharples, J. and Milham, N., Long-run Competitiveness of Australian Agriculture, *USDA Foreign Agricultural Economic Report, No. 243*, 1990, Table 1. The selected periods to which the figures (in brackets) apply are 1952-53 to 1956-67; 1962-63 to 1966-67; 1972-73 to 1976-77; and 1982-83 to 1986-87, respectively.
(d) ABARE (1990a).

TABLE 2
Measures of Productivity Growth in Australian Agriculture

	Time Period	Annual Productivity Growth Rate (per cent)	
ABARE (1990a)	1971-72 to 1988-89	2.0	
	(1968-69 to 1988-89)	(1.3)	(Manufacturing)
Martin and Savage (1988)	1965-66 to 1985-86	2.76	
Dixon and McDonald (1988)	1971-72 to 1986-87	2.32 (a)	
Powell and Milham (1990)	1950-51 to 1987-88	2.91 (b)	
Young (1971)	1949 to 1968	1.7	
Herr (1964)	1922 to 1959	1.2	
Mullen *et al.* (1992)	1953 to 1988	1.4 to 4.3 (c)	(Broadacre Agriculture
Lawrence and McKay (1980)	1952-53 to 1976-77	2.9	(Sheep Industry)
Beck *et al.* (1985)	1952-53 to 1982-83	2.7	(Sheep Industry)

(a) Measure of change in labour productivity for agriculture, forestry, fishing and hunting.
(b) Measure of annual growrh rate of gross farm output.
(c) Mullen *et al.* present eight estimates of total factor productivity growth. Each estimate is based on a particular type of index and model specification.

FIGURE 1
Farm Output and Farmers' Terms of Trade

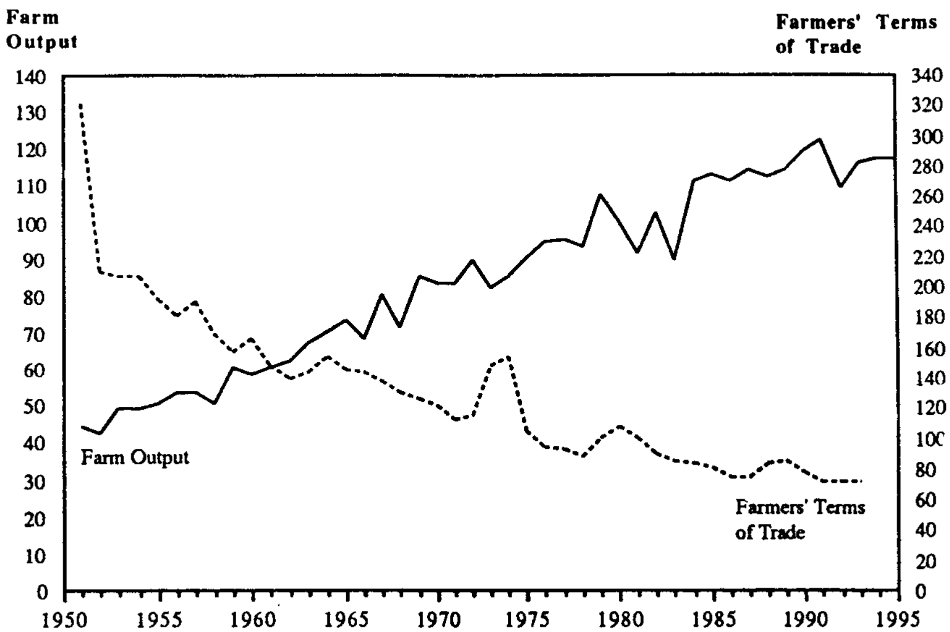


FIGURE 2
Real Values of Farm Output and Farm Costs

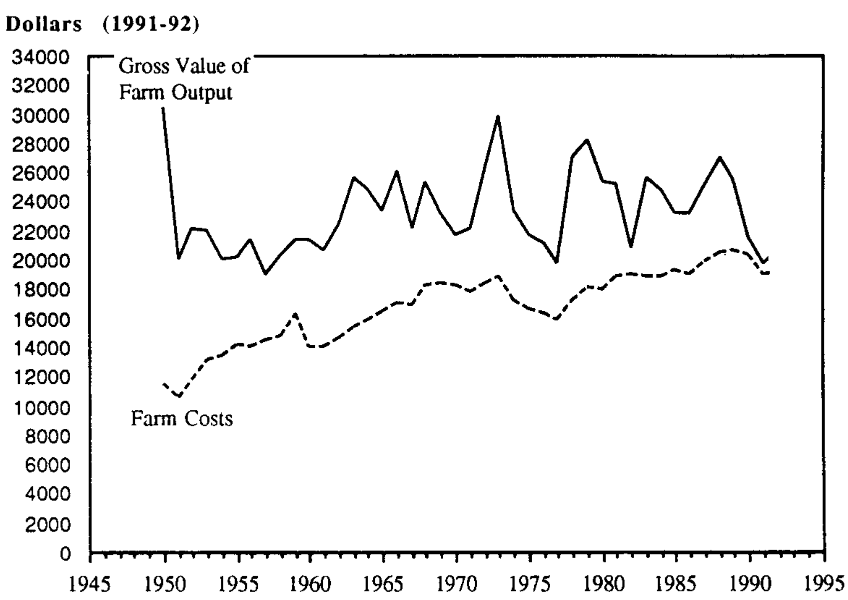


FIGURE 3

Real Farm Costs per Unit of Farm Output and Real Gross Value per Unit of Farm Output

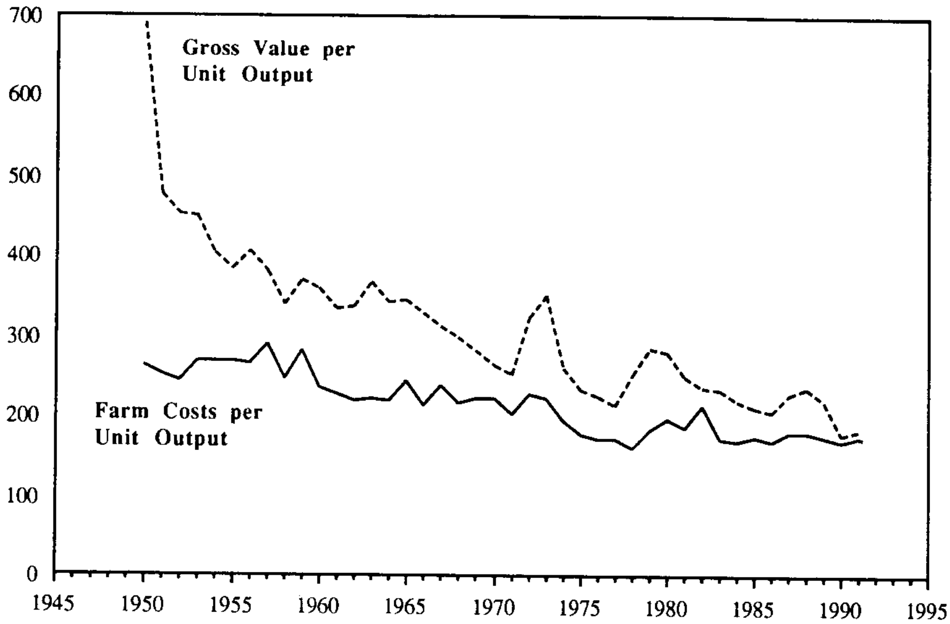
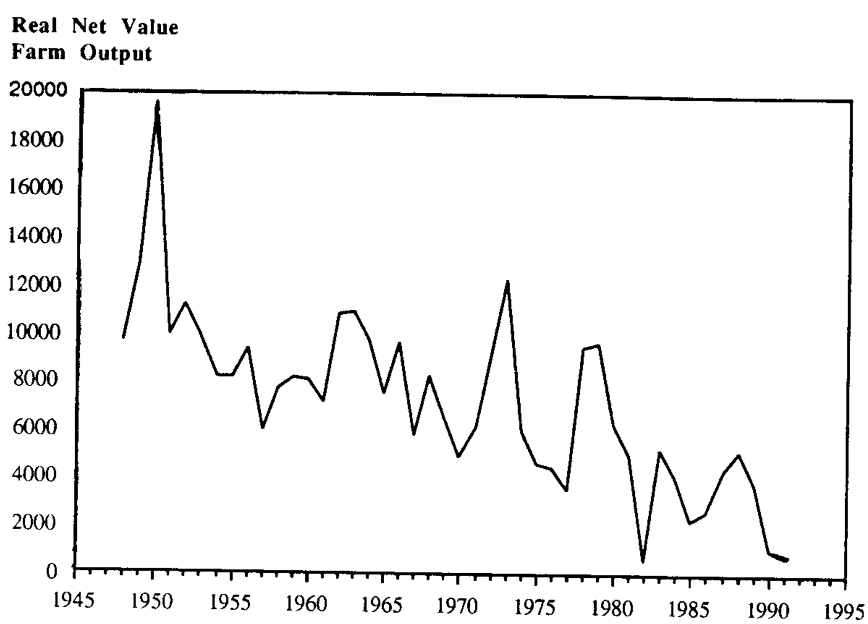


FIGURE 4

Real Net Value of Farm Output (1948-49 to 1991-92)



There has been a small downward trend in real farm costs per unit of output and a marked downward trend in the real gross value per unit of farm output (Figure 3). In contrast to the fairly strong positive growth rates of physical productive capacity, there has been a downward trend in the real net value of farm production as shown in Figure 4 and Table 3.[4] The real net value of farm production represents the residual return to self-employed farmers' labour and management, unpaid family labour, and capital investment in farmland.[5]

TABLE 3
Index of Real Net Value of Farm Production

Time Period (years)	Total (10 year averages)	Per Farm	No. of Farms (thousands)
1950-51 to 1959-60	100	100	204.4
1960-61 to 1969-70	84	86	199.1
1970-71 to 1979-80	77	87	181.6
1980-81 to 1989-90	42	64	135.0 (a)

Source: Derived from data in ABARE *Commodity Statistical Bulletins*, 1990 and 1991.
(a) My estimate, based on change made in procedure for estimating number of farms in 1986-87 (ABARE *Commodity Statistical Bulletin*, 1990, p. 19).

The substantial decline in the number of farms over the period 1969-70 to 1990-91 is not matched by a similar rate of decline in the self-employed and unpaid family helpers. If we assume that, unlike in the rest of the economy, there has been no increase in per capita real labour earnings for the self-employed and unpaid family helpers on farms, their proportion of the real net value of farm output appears to have declined, but not by a large amount. Consequently, the downward trend in the real net value of farm output shown in Figure 4 may overstate a little the extent of the decline in the residual return to total farmland.

The above residual return to farmland needs to be adjusted for changes in the total area of farms over time to obtain the residual return *per hectare*. Over the period 1950-51 to 1975-76 the total area of farms increased by about 14 per cent and since 1975-76 the area has declined by about 7 per cent. Hence, the residual return to total farmland understates the per hectare decline in the former period and overstates it in the latter period.

Adopting a residual valuation approach, there has been a decline in the share of farmland in agricultural production. I am not aware of a

[5] It should be noted that off-farm wages and off-farm income from other sources is a significant contributor to family income on many farms (Backhouse, Murtough, Nayar and Wiseman 1988). Even in a favourable farming year like 1989-90, average off-farm income was equivalent to about a third of average family farm income.

reliable empirical data series of Australia farmland prices over the last four decades which could be used to examine the extent to which actual movements in farmland prices reflect the decline in the real net value of agricultural production in Australia over the last four decades. Alston and Johnson (1988) have compared movements in farmland prices in the United States, Australia, Canada, New Zealand and Argentina. Empirical data on farmland prices were analysed for the period 1961 to 1980 for all countries except Australia where the period was restricted to 1971-80 owing to data limitations. For Australia, data for the state of Victoria was used. They concluded that, on balance, their results supported the modern theory of international trade insofar as they found a tendency towards similar movements over time of farmland prices in each country.[6]

The nature of technical change has an important influence on land values, yet this topic has received little attention in the research literature. A notable exception is Lopez (1988) who argues that the dominant impact of technological progress in agriculture is on output prices and land prices. A comprehensive analysis of technical change would account for the direct effects on factor shares and the indirect effects of technical change via induced changes in land prices and output prices. The indirect effects of technical change in some circumstances may dominate the direct effects and, thus, total technical change factor bias may be the opposite of a conventional microeconomic partial bias measure. For instance, contrary to the findings of previous studies, Lopez found for U.S. agriculture over the period 1950 to 1980 that technical change was labour intensive rather than labour saving. The direct effects of technical change (that is, the constant price effects) are a force reducing the share of labour. However, technical change has played an important role in lowering output prices and farmland values. The indirect effects arising from lower output prices and lower land prices are very strong and offset the direct effects. Lopez finds that most of the induced decrease in the share of land arises from a large depressing effect of technical change on land prices.

In an early Australian study, Gruen (1960) was clearly aware of the importance of the indirect effects of technical change when he argued that the innovation of improved pasture had not necessarily been an economic benefit for the wool industry or for Australia. More recent studies which have examined the nature of technical change in

[6] Alston and Johnson also found that their results lent support to the hypothesis that the primary determinant of farmland prices is expectation of future farm net income flows rather than the inflation-portfolio type of model proposed by Feldstein (1980).

[7] Mullen *et al.* indicate that an area of concern in their study is that expenditure on inputs exceeded gross farm revenue in every year from 1981 to 1988. They recognize that such a long run of negative profits cannot be explained by unexpected price movements or weather conditions, and that it is not consistent with profit maximising behaviour. This result probably reflects the fact that there is not a reliable set of Australian data on farmland values over time. A residual valuation approach for farmland is likely to be superior, and it would give different results for both measured rates of technical change and bias of technical change.

Australian agriculture provide conflicting results. McKay *et al* (1982) found that technical change in Australia's wheat-sheep zone was land-saving. This finding contrasts with that of Mullen *et al* (1992) who found that technical change was land-using for Australian broadacre agriculture.[7] Land-using technical change, *ceteris paribus*, will have a more favourable impact on farmland values than land-saving technical change.

Farm Capital and Investment

Investment provides an important vehicle for introducing new technology into production systems. Powell and Milham (1990) present data for capital stock and net investment in Australian agriculture over the period 1949-50 to 1986-87. The first year of negative net investment over this period occurred in 1976-77. Apart from two years of small positive net investment in 1978-79 and 1979-80, net investment was negative in every year over the period 1976-77 to 1986-87.

Knopke and Harris (1991) and Knopke and Wittwer (1992) found that capital expenditure on farms followed a declining trend during the 1980s. Over the period 1982-83 to 1990-91 they show that there has been negative net investment in broadacre farm plant and equipment in almost every year. In 1990-91, capital expenditure on new plant, machinery, buildings and structures declined by an estimated 35 per cent.

The low level of capital expenditure in Australian agriculture over the period 1976-77 to 1991-92 is striking and it would appear to have significant implications for future productivity. However, more research is required before informed statements can be made about the implications of low capital expenditure on future productivity of Australian agriculture. It is important to note, for instance, that real interest rates, and thus the user price of capital, were at very high levels over the period 1980 to 1991, providing an incentive for farmers to adopt production methods that are capital saving. In Australia, as in other developed countries, the general technological trend in agricultural production has been one of substitution of capital for labour.

Land Degradation

There has been much debate about land degradation, but there remains a paucity of Australian research data which links physical measures of land degradation to productivity losses. We talk about land degradation but we do not really know the extent to which it is reducing our capacity as a nation to produce food and fibre (Chisholm 1990; Dumsday and Chisholm 1991). Davidson (1991) and Uren (1992) suggest that clear thinking and logical argument have been absent in much of the debate on land degradation in Australia and that many of the claims that have been made about the severity of the problem are exaggerated or motivated by self-interest or strategic/political considerations. Uncertainty about the seriousness of land degradation is not only a problem in Australia. Nobel Laureate T. W. Schultz (1982) questions the importance of soil erosion in the United States. 'Most of the flood of so-called evidence is highly politicised and self-serving. Major urban newspapers and other media are bent on showing that soil erosion is catastrophic. These stories, as a rule, have a political axe to grind' (p. 2).

A recent 'guesstimate' that has been widely quoted puts the cost to Australia from lost agricultural production attributable to land degradation at about $600 million a year[8] (1988-89 dollars) (Commonwealth of Australia, 1989). The above guesstimate may be added to the gross value of agricultural production in 1988-89 and the annual growth rate recalculated for the adjusted gross value of farm production over the period 1951-52 to 1988-89 (at constant 1988-89 prices). If we assume (unrealistically) that all the land degradation occurred after 1952, and that it could have been completely and costlessly prevented, the annual productivity growth rate would have been about only 0.1 per cent higher than the growth rate (around 2.5 per cent) actually achieved. In other words, cumulative growth of the gross value of farm production has added around $15 billion a year to total farm receipts (at constant 1988-89 prices) whilst it is estimated that land degradation costs around $0.6 billion a year. Even if we double the above guesstimate, the increase in the physical productive capacity of Australian agriculture from 1950-51 to 1988-89 dwarfs the estimated on-site production loss resulting from land degradation. This is not to say that land degradation has only a tiny impact on farm incomes. The average Australian farm net value of agricultural production in the relatively buoyant year 1988-89 was around $34,381 (1988-89 dollars). If the above estimate of the aggregate cost of land degradation was used, the average value per farm of the loss of agricultural production due to land degradation would be around $4,800.[9]

Whilst Australian agriculture has a strong overall record of productivity growth, some regional problems can be identified. In Queensland's arid rangelands, Passmore and Brown's analysis reveals that a strategy of high stocking rates with the potential for rangeland degradation is the optimal private response given the economic and

[8] Hall and Hyberg (1991), using data from an ABARE survey of farmers of their farms' land degradation status estimated that in 1983-84, farmer perceived land degradation lowered farm revenue by $393 million. This is equivalent to, about $554 million in 1988-89 dollars.

[9] In a well-functioning market for farmland, this cost is significant enough for differences in degradation levels between farms to be reflected in different market values. King and Sinden (1988) lend support to the hypothesis that the market for farmland does operate sufficiently well for between-farm differences in levels of land degradation to be reflected in different market values, at least for the more visible types of land degradation.

social factors that confront many graziers. Henzell (1992) states that there is evidence of a yield plateau for the last twenty years in the Australian sugar industry despite the adoption of newer, potentially higher-yielding varieties, and that the problem is probably to do with the soil. Henzell also points out that in southern Australia graziers and their advisers have claimed for at least a decade that the productivity of their legume-based pastures has declined. Williams (1989) examined historic trends in Australian wheat yields and concluded that gains in productivity from plant breeding and improved management practices are barely keeping up with declining soil quality.[10]

I now develop a simple comparative static supply and demand framework for land quality and analyse the impact of some selected rural policies on long-run land quality.[11] From the viewpoint of commercial agricultural production, land quality has many characteristics: depth of topsoil, soil structure, soil chemical composition, organic content, drainage, soil biology, and topography. In a well-functioning land market shadow prices would be linked to each quality characteristic and to location (Lancaster 1966 and Rosen 1974).

In the simplified analysis which follows it is assumed that land consists of two components:

(i) a physical area or stock of land which is assumed to be fixed in perpetuity; and

(ii) a quality-adjusted component which may be increased by investment in measures that enhance land quality or can decrease with more intensive use of the land resource.[12]

The quality-adjusted component of land may be enhanced for instance by drainage, contour banking, or build-up of organic matter and consequently more stable soil structure under improved pastures. Davidson claims that the reason for the more than doubling of agricul-

[10] The growth of interest in organic farming in Australia also reflects a concern about the sustainability of 'conventional' agriculture. For a recent discussion of organic farming see Marshall (1991).

[11] The remainder of this section of the paper provides a fairly detailed and self-contained qualitative analysis of the impacts of particular government policies on long-run land quality. Some readers may prefer to proceed directly to the next section of the paper.

[12] Chambers and Reichelderfer (1988) use an intertemporal extension of the Ricardo-Viner model in which the economy consists of two sectors: the agricultural sector and the non-agricultural sector. A small open economy is assumed in which the output of each sector is produced by combining a sector-specific input, or vector of inputs, with a variable factor of production that can be devoted to the production of either output. More intensive use of the land resource is assumed to diminish land quality while investment in land increases land quality. Chambers and Reichelderfer adopt a dynamic framework, but illustrate their results with long-run supply and demand figures for land quality which are similar to the comparative static framework I adopt. The author has also gained valuable insight into conceptual and theoretical issues of land degradation, particularly the impact of level of product price on long-run land quality, from discussions with both Harry Clarke and Jeffrey La France. See their papers in this issue of the *Journal.*

tural output over the last four decades is because the fertility of the land 'which produces 90 per cent of Australia's agricultural commodities is much higher today than when European settlement first occurred (p. 25).' On the other hand, more intensive application of variable inputs (e.g. irrigation water, grazing pressure, or cultivation) increases yields in the short-term, but commonly reduces some components of soil 'quality' over the long-run.

In 1978 I argued that 'subsidies (for structural forms of soil conservation) will induce more investment in soil conservation, but at the same time, they are likely to increase the *need* for more investment in soil conservation' (Chisholm 1978, pp. 7-8). The essential point was that such subsidies reduce the private cost of the long-run supply of soil quality and thus provide an incentive for farmers to adopt more intensive, and potentially more degrading, uses of land. For example, farmers may increase stocking rates, switch from pasture to more erosive cropping, or increase intensity of crop cultivation. Subsidization of investment in conservation structures shifts the long-run supply for land quality downward to the right. The resultant lower shadow price of long-run land quality encourages more intensive use of the variable input (e.g. higher grazing pressure) which eventually degrades land. The incentive given toward more intensive land use constrains the overall improvement in long-run land quality attained by investment in land-conserving structures.

A higher discount rate lowers the present discounted value of the future marginal productivity of land, i.e. the present value of future units of soil quality. The long-run demand for land quality shifts downward to the left. The shadow price that farmers would pay for future units of land quality is lowered, which results in lower long-run land quality. The high real interest rates over the 1980s were a disincentive for investment in soil conservation.[13]

Costin and Coombs (1981) and others have argued that the superphosphate bounty (phased out in 1988) encouraged the use of fertilizer at the expense of alternative management and production systems which might be more consistent with maintaining good soil quality. We now know that continuous application of superphosphate and nitrogenous fertilizers on improved pastures can contribute to an increase in soil acidity over time. Similarly, it has been argued that subsidising the use of irrigation water in Australia can lower long-run soil quality owing to the on-site effects (our present focus) of waterlogging, soil structural decline, and salinity. Another important example is the use of subsidies for fodder to combat the effects of

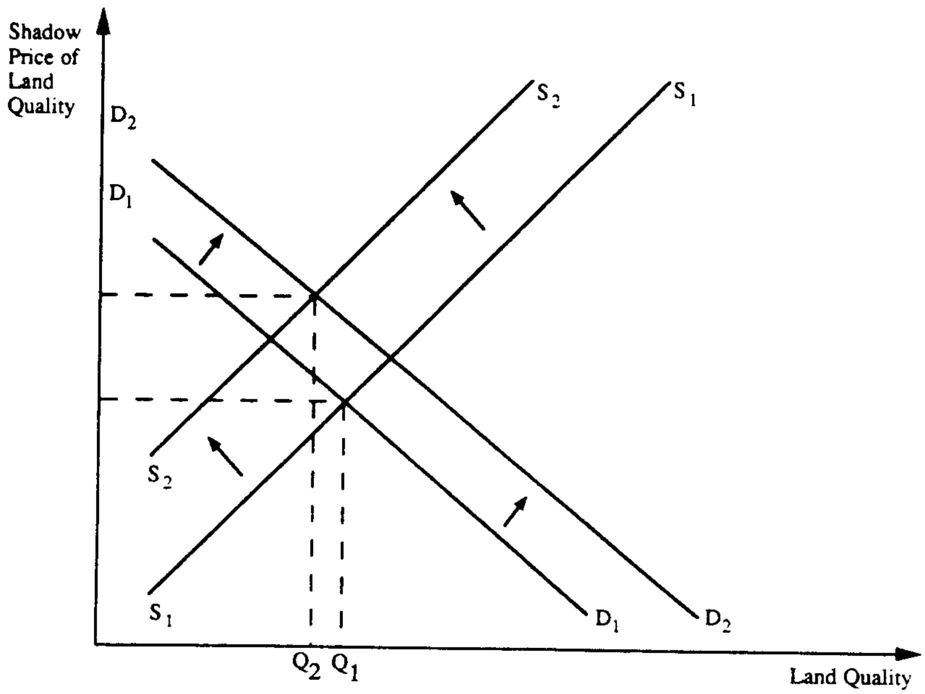
[13] In many respects, the issue of an appropriate rate of social discount, and whether or not there is a divergence between this rate and the market rate, is central to the debate on sustainability and intergenerational equity, but this topic is beyond the scope of this paper. Ultimately, the discount rate issue is linked to the question of the adequacy of current aggregate levels of saving and investment.

drought. A drought fodder subsidy favours retention and supplementary feeding of livestock on farms relative to other strategies of a conservative stocking rate, destocking via animal sales and animal deaths (Freebairn 1983). Such subsidies may exacerbate soil degradation problems by providing an incentive for farmers to adopt higher stocking rates because the private cost of feeding livestock in low rainfall years is lower.

The initial impact of a subsidy on the use of water for irrigation is to lower the private marginal factor cost of the resource below its marginal value product. Hence in the short-run, utilization of the variable input in agriculture will increase and agricultural output and farm incomes will rise. If more intensive water use causes degradation in the form of waterlogging, soil structural decline and salinity, the long-run supply of soil quality will shift upward to the left. However, subsidizing the use of irrigation water increases the long-run demand for land quality, since land suitable for irrigation now has lower cost irrigation water to complement it in production. Consequently, as shown in Figure 5, the long-run shadow price of land quality rises and this provides an incentive for more investment in conservation measures (e.g. drainage systems) to improve land quality. The shifts in supply and demand both exert an upward influence on the long-run shadow price of land quality. However, the ultimate sign and magnitude of the impact of a subsidy on irrigation water (or any other variable input) is an empirical issue. Farmers are simultaneously being pulled in two different directions by the subsidy. The subsidy makes irrigible land a more valuable resource, but at the same time encourages more intensive land use. If a very effective but costly conservation technology is available to combat the longer-run land degrading effects of irrigation, the higher long-run shadow value of good quality irrigible land, resulting from the subsidy, may stimulate sufficient investment in conservation measures so that the potentially degrading effects of more intensive water use are more than offset. That is to say, long-run land quality would be higher with the subsidy than without it. On the other hand, if no, or only a partially effective conservation technology is available, the subsidy would lower long-run land quality. Similarly, a superphosphate subsidy may conceivably so increase profitability and the long-run shadow price of land quality, that liming becomes an economical measure for maintaining acceptable levels of soil acidity.[14]

[14] In a different context, it is relevant to note that Wang and Lindner (1990) found in Western Australia's arid zone rangelands that optimal policies involved a strategy of grazing management only. Even for severely degraded rangeland, rehabilitation by reseeding was found not to be economically viable at the current cost and revenue levels. However, a significant reduction in the costs of the cultivating and reseeding technology, or an increase in output prices, could result in an optimal combined policy of stocking intensity and reseeding.

FIGURE 5
Long-run Effects of Subsidies for Irrigation Water Use (Fertilizer Use) on Land Quality and Shadow Price of Land Quality



The preceding analysis is a positive one. On efficiency grounds, there is no case for subsidization of agricultural inputs (including those that contribute directly to improving land quality) unless some form of market failure can be identified. The major forms of market failure associated with the use of irrigation water are the well known off-site negative externalities which would require a tax, not a subsidy, to equate marginal private and social costs. A negative externality that is perhaps not well-known, is that in some regions of Australia, subsidization of the use of water in agriculture creates a condition of water scarcity in the metropolitan, residential and industrial sectors. The response of metropolitan water boards to this condition of 'artificial' water scarcity will commonly involve development of additional water catchments with associated environmental costs.

Finally, it should be recognized that technological innovation in water use (and in other activities) is endogenous in the sense that it responds to the pattern of distorted water prices and particularly toward technologies that are water intensive. An extreme example, currently practised by some Australian farmers, is to apply very large inputs of 'cheap' irrigation water as a means of flushing salts from the soil profile and thus reducing 'on-site' salinity. The negative off-site effects generated by such practices are likely to be substantial.

The Declining Economic Importance of Agriculture

The proportionate decline in the agricultural sector during economic growth is usually explained mainly in terms of demand-side factors. The phenomenon known as Engel's Law (Schultz 1953) predicts that as income per capita rises there will be a relative decline in food prices and consumption expenditure will shift towards manufactured goods and services relative to food. While the predicted changes are most clearly seen in the context of a single country with a closed economy, the same mechanism operates at a world level. Low income elasticities of demand for food relative to other traded goods will result, *ceteris paribus*, in declining international prices of food relative to other traded goods over time. It is of interest to consider the empirical evidence, firstly for the two major staple food commodities, wheat and rice. Edwards (1988) finds that real world wheat prices have declined absolutely since the middle of last century. Prabhu Pingali (1988) concludes that real world rice prices have declined since the end of World World II. On the basis of data compiled from World Bank files and other sources, Tyers and Anderson (1992) found that real international prices of food declined over the period 1900-1987. Anderson (1987) also concludes that the weight of evidence seems to support the view that agricultural prices have declined relative to manufactured goods prices.

For a small trading country, relative prices of traded goods in food and manufactures are independent of domestic demand or supply conditions. However, the level of the prices of traded goods relative to those of non-traded goods and services, are affected by domestic demand. Income elasticities of demand for services are typically greater than unity, which implies that the aggregate of other goods — largely traded goods — has an income elasticity of demand lower than unity. It follows that as economies develop, we would expect to observe a decline of the prices of traded goods relative to those of non-traded goods prices (Anderson 1987).

For the world economy as a whole, and for a closed national economy, the demand-side factors are a force toward causing a decline in agricultural product prices relative to the prices of other goods and a fall in agriculture's share of GDP. For a small growing economy in an open global economy a decline in agriculture's share of GDP could only be avoided if the country's production possibility frontier, for agricultural and non-agricultural goods, becomes increasingly skewed through time in favour of agriculture. As we have seen previously, the measured rate of productivity growth in Australian agriculture over the last four decades has been high relative to both the rate of productivity growth for the non-agricultural sector of the Australian economy and to the average rate of productivity growth in the agricultural sectors of other developed countries.

Nevertheless, over the period 1950-51 to 1990-91 there has not been a significant upward trend in the real gross value of Australian farm output and agriculture's share of GDP has declined from around 18 per cent in the early 1950s to a little under 4 per cent in the late 1980s. Over the same period, agriculture's share of total exports declined from around 85 per cent to about 35 per cent. Moreover, the real net value of farm output has trended downward. Much of the strong growth in supply of agricultural products in the rest of the world has been stimulated by high levels of agricultural subsidies. The formation of the EEC with a highly protectionist CAP, and to a lesser extent, the more recent export enhancement policies of the United States, have unquestionably had a very adverse effect on the fortunes of Australian farmers. Policies like the CAP also exacerbate the impact of natural fluctuations in world production on world price volatility (Chisholm and Tyers 1985). Another downward influence on world agricultural commodity prices stems from the common practice in growing economies to change from taxing to subsidising agriculture, relative to manufacturing, as low-income economies develop into high-income economies (see, for instance, Tyers and Anderson (1992).

Recently, Martin and Warr (1990) have focussed on another possible influence on the size of the agricultural sector, namely, changes in the total supply of labour and capital in the economy. Rybczynski's theorem (Rybczynski, 1955) states that changes in factor supplies are likely to induce changes in the output mix when the factor intensities of the agricultural sector and other sectors differ. The accumulation of capital per worker as economic growth proceeds will tend to encourage expansion of the more capital-intensive sector at the expense of the more labour-intensive sector. Thus, if agriculture is more labour intensive than the rest of the economy, then a rate of capital accumulation which is greater than the rate of increase in labour will cause agriculture's share of output to fall. For Thailand, Martin and Warr found that changes in that economy's stocks of capital and labour, and a possible bias against agriculture in technical change, accounted for around three quarters of the total decline in the share of agriculture in the economy.

In Australian agriculture, there has been a high rate of substitution of capital for labour although this trend appears to have been reversed during the decade of the 1980s, a period of high user cost of capital. It seems unlikely that changes in stocks of capital and labour (Rybczynski's theorem) would account for much of the decline in the share of agriculture in the Australian economy. However, it is pertinent to note that the mining industry is a very highly capital intensive sector, which has grown rapidly in Australia over the last two decades. Over the period 1969-70 to 1989-90 the contribution by the mineral sector to total Australian exports increased from 27 per cent to 41 per cent whereas the contribution from agriculture declined from 44 per cent to 24 per cent. In any event, it would be difficult to separate effects of changes in Australia's stocks of capital and labour (Rybczynski) from the real exchange rate effects caused by the growth of the mineral export sector (Gregory, 1976), when accounting for the decline in the share of agriculture in the Australian economy. The growth of the mineral sector has certainly caused a decline in the share of agriculture in the economy and it has most likely lowered aggregate real net farm income.

Some commentators argue that the exchange rate is out of line with fundamentals and that an 'over-valued' exchange rate has discouraged exports. The proposed solution is to engineer a depreciation of the Australian dollar to a level consistent with economic fundamentals. However, Whitelaw and Howe (1992) emphasize that changes in domestic spending, relative to output, influence the level of the real exchange rate. In particular, a lower saving rate means that domestic demand increases relative to domestic supply and this causes the price of non-traded goods to be pushed up relative to the price of traded goods. The associated real appreciation of the $A encourages the switch to imports and dampens exports. From the mid-1970s to the mid 1980s Australia's rate of net-saving was significantly below the OECD average and Whitelaw and Howe suggest that the increase in Australia's current account deficit over this period was in large part attributable to the decline in Australia's rate of saving.

Finally, future environmental controls applying to Australian agriculture and to our major trading competitors may have significant effects on Australia's long-run competitiveness in agriculture. In terms of 'willingness-to-pay', a high-quality environment is more highly valued as real incomes rise. Generally speaking, high-income countries will have greater pressures than low-income countries to correct market failure associated with the supply of environmental services through government intervention in the form of direct environmental regulations or market-based incentives. In countries with strong environmental regulations applying to agricultural production, private costs of production will rise relative to those with weak environmental quality standards, and trade competitiveness will tend to be reduced in such countries. Of course, providing that private costs are in line with social costs, the above result is entirely consistent with a goal of Pareto efficiency. With a growing population and rising real incomes, the value of renewable natural resources for non-agricultural uses is likely to grow relative to their value in producing food and fibre. For instance, there will be increasing pressures and willingness to pay for protecting our inland and coastal waterways (Chisholm, 1990).

Abler and Shortle (1990) present some interesting quantitative results derived from a partial-equilibrium simulation model of agriculture containing three regions: the United States, the European Community and the rest of the world. A 10 per cent reduction of chemical use in the US and the EC (with existing farm programs) is predicted to increase world grain prices by around 40 per cent in the medium run and by about 5 per cent in the long run. In the US, land rents increase because higher product prices, combined with the substitution effect of land for chemicals, outweigh the negative effect of output reductions on the demand for land. In the EC, land rents were predicted to fall in the medium run as a result of the negative output effects of cost increases dominating the substitution effects of land for chemicals. In the long run changes in land rents were negligible.

Concluding Comments

Over the last four decades, Australian agriculture has achieved a favourable productivity growth rate relative to the rest of the Australian economy and to the average growth rate for agricultural sectors in other developed countries. Farm output increased two and a half times and real costs per unit of farm output declined. However, Australian agriculture has been a declining industry, in terms of the real net value of farm production.[15] The real net value of farm production in the first two years of the 1990s is the lowest experienced for consecutive years over the period 1948-49 to 1991-92. Whilst there is a fair chance that this will prove to be the low point for the rural sector in the 1990s, annual real net values of farm output are expected to remain at historically low levels over the new few years. At the end of the 1990s, it is likely that the annual average real net value of farm output in each decade will have declined over five consecutive decades.

If trends in total factor productivity, or per unit real costs of production, are used as a measure of sustainability, Australian agriculture has been most successful despite some production loss attributable to land degradation. However, when a more relevant economic measure of sustainability of Australian agriculture is adopted, such as the trend in the ratio of the real gross value of farm output over real farm costs, or the real net value of farm output, there has been a striking decline in Australian agriculture.

The Australian annual time series data on total farm capital stock and farmland values is very imperfect. Nevertheless, it is apparent that in recent years there has been an unprecedented fall (at least since the time of the Great Depression) in the real value of total farm capital stock. Economic depreciation of the total stock of farm capital and the apparent depreciation of farmland values, cannot be attributed to poor management of agriculture's natural resource base. From a national

[15] The focus in the paper has been on the performance of Australian agriculture as a whole. For recent surveys of the physical and financial performance of individual sectors within Australian agriculture, see ABARE (1990b) and annual ABARE *Farm Survey Reports*.

perspective, loss of agricultural production due to land degradation, appears to be small relative to the overall increase in productive capacity arising from technological innovation and management changes. Moreover, the land degradation which has occurred does not necessarily imply market failure, or government failure, although with the benefit of hindsight we know that mistakes were made by both farmers and government. Furthermore, estimates of the production loss attributable to land degratation do not inform us what corrective actions, should be taken; marginal benefits need to be balanced against marginal costs.

The decline of agriculture's share of GDP in Australia can be explained in terms of the well known demand-side factors operating during economic growth and the growth of the mineral sector. But the absolute economic decline in agriculture over the last four decades is difficult to explain fully. The fact that there has been a relatively high rate of technical change in Australian agriculture, associated with a decline in real per unit costs of production, suggests that demand-side factors are the cause of the absolute decline in the real net value of farm production. In particular, the formation of the EEC with a highly protectionist CAP, and to a lesser extent, the more recent export enhancement policies of the United States, have substantially lowered world agricultural commodity prices. The outcome of the Uruguay Round of trade negotiations will be an important factor influencing the future fortunes of Australian agriculture.

How should we interpret a decline in the value (economic depreciation) of Australia's renewable resource base for agricultural use? In a closed-economy, such a decline would signal that technological advance had increased economic welfare by lowering food and fibre prices and reducing both the scarcity of farmland and the opportunity costs of using land for other purposes, such as state and national parks. In an open-economy, with an export-orientated agricultural sector, a decline in the real net value of farm output attributable to a decline in world prices, lowers a country's economic welfare. The very low residual returns to Australian farmland experienced in recent years threaten the sustainability of Australian agriculture. If low residual returns to Australian farmland persist, farm output is likely to contract and a substantial restructuring of the rural sector will be ineviatable. In these circumstances, in a world of perfect foresight an optimal strategy would have been to exploit the land more intensively during the buoyant years of the 1950s, 60s and early 70s, even at the cost of greater land degradation, providing that irreversible land degradation did not occur, particularly on land that had a potential future high value in non-agricultural use. The impact of lower returns to Australian farmland on long-run land quality is difficult to predict. Land that remains in agricultural use will be used less intensively, but there will be less incentive to invest in soil conservation measures which improve long-run land quality.

Almost all increases in global agricultural production in the future must come from further intensification of agricultural production on land that is currently devoted to crop and livestock production. There is a widely held view that for the next twenty years or so, gains in crop and livestock productivity will continue to be generated by improvements resulting from conventional plant and animal breeding techniques and from more efficient use of inputs (Ruttan 1989). Moreover, the productivity sources are likely to come in smaller increments, earned with more difficulty than in the past. In Australia, scientists and farmers are concerned about yield patterns in the wheat and sugar industries and an apparent decline in the productivity of legume-based pastures in southern Australia. However, major breakthroughs in, say genetic engineering, for both plants and animals over the longer-run, could result in dramatic gains in productivity. There is, of course, substantial uncertainty surrounding these issues.

The role of demand-side factors will continue to be crucially important for Australian agriculture, but there is little that the rural sector or government can do to influence these factors. On the supply-side, the rate of future productivity growth attained in our agricultural sector, relative to the rates achieved by our trading competitors, will be an important factor influencing the size and the net value of our agricultural output. It will be a challenge to institutional innovation in Australia in the next fifty years to design the institutions that can achieve the technical and management advances in agricultural production and marketing which are necessary to maintain international competitiveness, and to design institutions and policies that are capable of ameliorating the negative environmental spillover effects arising from agricultural production.

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