Australian Economic Development and the Environment: Conflict or Synergy*

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ABSTRACT

The populist view of economic development and the environment is that advances in one will necessarily result in a decline in the other. Evidence in the Australian context is that the dual goals can be achieved simultaneously.

As economic development progresses, the increasing levels of income stimulate greater demand for environmental improvements. The population engages in more environmentally focused consumption and calls for its governments to introduce more policies designed to rehabilitate and protect environmental assets. Concurrently, the increasing levels of wealth allow for increasing expenditure on research and development into production processes that generate greater productivity and less environmental damage.

The Australian agricultural sector provides numerous examples of concurrent improvements in productivity and environmental condition. Zero tillage broad acre grain cultivation practices have led to lower rates of soil erosion and have enriched soil biota while delivering higher productivity. Similarly, the introduction of integrated pest management, including the planting of pest and herbicide tolerant species, has improved water quality in cotton growing areas.

A key implication from this analysis is that policies to improve environmental conditions should not be focused on stifling economic growth. Rather, governments should strive for policies that will encourage economic growth – such as the installation of property rights that are both well defined and defended. Concurrently, policies specifically designed to deal with potential environmental problems should be enacted. For instance, the establishment of property rights to water and the setting aside of allocations for environmental flows will encourage both economic development and environmental protection.

***Key words**: economic development, environmental protection, agriculture, policy*

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1. The State of the Environment … and the Economy

The Australian media continually features reports that announce the perilous state of the environment, locally and internationally. The threat of species extinction, declining river health and the threats posed by global climate change are regular contributions to the public's perception of environmental doom and gloom. Concurrently, rates of economic growth have been consistently at the high end of OECD country performances.

The casual empiricist would be tempted to draw the conclusion that the economic growth is being achieved at the expense of the environment.

A more considered analysis reveals a different picture. There is no doubt that Australia has become a more economically prosperous society over the last 20 years. Gross Domestic Product per capita has risen from A$7,519 in 1986 (in 2006 dollars) to A$47,181 twenty years later (ABS 2007). The average growth rate of GDP for the past four quarters was 3.8 per cent compared to an OECD average of 2.7 per cent (OECD 2007). However, empirical evidence also suggests that environmental conditions are not necessarily universally declining. For instance, the number of Sydney beaches that have achieved 100 per cent compliance with "Beachwatch" criteria for faecal coliforms and enterococci levels has gone from seven in 1999 to 29 in 2006 (EPA 2000 and 2006). Methane gas emissions have fallen from 117,457 tonnes in 1990 to 112,992 in 2005 (DEWR 2006). The amount of carbon stock loss from soils has also fallen from almost 5m tonnes in 1994 down to less than 1.5m tonnes in 2004 (DEWR 2007). The amount of nitrogen licensed for release into inland waterways in NSW fell from around 1,750 tonnes in 2001 to 500 tonnes in 2004 (DEC 2007).

This analysis provides an alternative conclusion … that economic development and environment protection can be synergistic.

Notwithstanding the evidence of environmental improvements over the past 20 years, it is also clear that the Australian environment is significantly degraded when compared to its pre-European settlement condition. Species have been driven to extinction. Water quality and fish populations in Australian rivers have declined. Sydney's air quality is worse than when Captain Cook landed in 1770. Furthermore, the deterioration in some elements of the environment are continuing up to the present time. For instance, the number of Australian fauna species listed as 'endangered' has increased from 98 in 2000 to 121 in 2006 (ABS 2006). The level of particulate concentration in Sydney air has similarly not shown significant improvement being 45.1$\mu g/m^3$ in 2000 and 41.8 $\mu g/m^3$ in 2004, with considerable fluctuations in the intervening years (ABS 2006). CO_2 emissions have also been rising through time: from 279,764 tonnes in 1990 to 384,161 in 2005 (DEWR 2006). Hence, the environmental improvements that have been observed over the last 20 years have been, to some extent, part of a recovery process.

The apparent contradictions in these conclusions relating to the relationship between economic growth and environmental condition are the focus of this paper. An attempt is made to reconcile the somewhat conflicting observations made above. First, a conceptual

framework that links economic performance to environmental condition is established. Second, evidence from a number of case studies across Australian agriculture is used to illustrate the concepts.

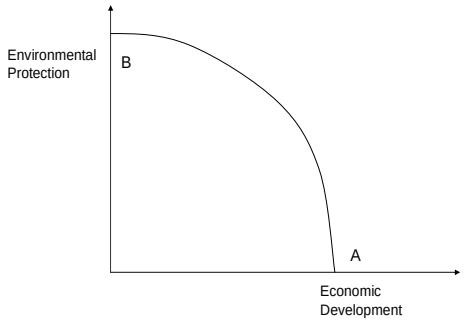
2. Production Possibilities

A central tenet of economics is that resources are scarce. As a consequence, choices regarding how resources are to be used have to be made. Hence, Economics 1 textbooks (such as McTaggert, Findlay and Parkin 1999) present such choices as trade-offs between alternative production options. For example, society may have to make a choice between the use of its resources, say for the production of either guns or butter. In order to produce more guns, fewer resources will be available for the production of butter.

Similar choices must be made in the broader context of allocating resources between economic development and environmental protection uses. For instance, a forest can be set aside as a nature reserve or it can be harvested for its timber. Coal can be burnt to generate electricity to light and heat houses or it can be left in the ground without releasing any carbon dioxide into the atmosphere. Water can be diverted from a river to irrigate crops or it can be allowed to remain 'in-stream' to maintain wetland health.

This type of trade off can be depicted diagrammatically by what is known as a production possibility frontier (see Figure 1). The frontier illustrates the combinations of economic development and environmental protection that are technically possible within a society, given the resources that are available to it at any particular point in time

Figure 1: The Production Possibility Frontier.



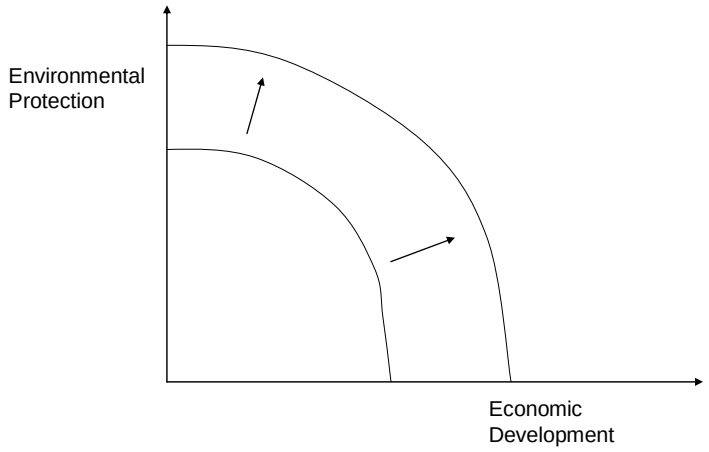
Society faces the task of selecting the combination of economic development and environmental protection that is optimal. Having both maximum possible economic growth (point A) and maximum environmental protection (point B) is not possible.

Sacrifices of both are required. The key issue facing society is striking the right balance between the options available.

It is because economics has pointed out the presence of the sacrifices in the choices society must make that it became known as the 'dismal science'. If an increase in economic growth is required, it will come at the cost of some environmental degradation.

However the news is not all bad. The production possibility frontier represents the trade offs presented to society given the resources available at a particular time and the factors that impact on resource productivity. Hence, if additional resources can be discovered or their productivity increased, the potential for an outward shift of the production possibility frontier is established. In turn, such a shift allows the potential for improvements on both economic growth and environmental condition (see Figure 2).

Figure 2: Shifting Production Possibility Frontier.



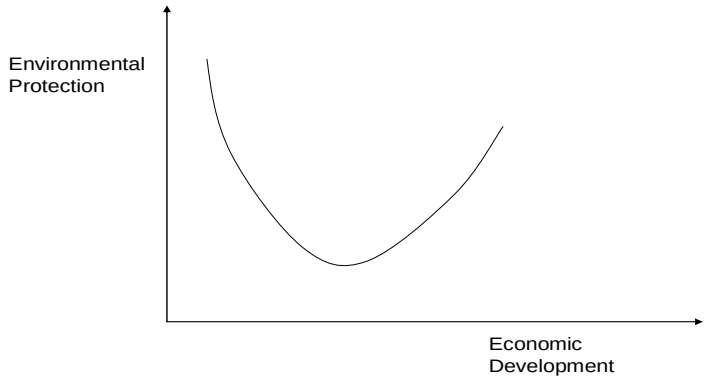
The desirability of avoiding trade-offs and the achievement of 'win-win' outcomes is obvious. Less clear is the processes that would initiate and sustain outward shifts in the production possibility frontier.

3. The Environmental Kuznets Curve

Some insight into these processes can be gained from a consideration of the literature that has developed around the concept of the Environmental Kuznets Curve (EKC) (Pearce and Barbier 2000). The central tenet of the EKC is that as economic development

increases, environmental damage increases, but after a point, this trend in damage is reversed. Figure 3 depicts this relationship.

Figure 3: The Environmental Kuznets Curve.



The implication of the EKC is that if a society can achieve a threshold level of economic development further environmental damage will be halted and existing damage will be repaired so that overall environmental conditions will be improved. Again, this represents a desirable outcome in which environmental improvements are achieved alongside economic growth. However, the challenge society faces is to discover what factors are precursors to achieving the threshold. It is not sufficient to presume that the pursuit of economic development will automatically precipitate a turn around in environmental performance. Furthermore, if society can initiate measures to bring forward the threshold point in its economic development, some environmental damage can be avoided. This may be particularly important if the environmental damage is 'irreversible' such as is the case with species extinction.

It would be problematic for society to pursue economic development under the presumption that it will eventually precipitate environmental improvements if along the way, a sequence of irreversible, negative, environmental impacts were created that both diminished society's well-being from the environment and precluded future economic development options. Irreversible and catastrophic climate change would be an example of such an event.

While the links between economic development and environmental improvement are not automatic, the process of economic development is a precursor to achieving the turn

around. It is similarly integral to the shifting outward of the production possibility frontier.

4. Production and Productivity

To understand the relationship, consider the factors that are integral to the productivity of natural resources. Production is necessarily a process of combining different forms of capital … natural capital, manufactured capital, human capital and social capital. More production can be achieved if the stocks of any of these forms of capital can be enhanced. For instance, if education levels can be enhanced, the production levels achievable given fixed natural capital can be increased – smarter workers and management plus the results of research and development are productivity enhancing. Additions to the stock of manufactured capital – higher technology machinery – applied to natural resources can increase productivity. New technology associated with oil exploration and extraction has allowed an expansion of the stock of economically feasible crude oil. Developments in the functioning of the internal combustion engine have seen fuel consumption rates diminish significantly. Finally, improved levels of social capital – particularly strengthened institutional structures such as property rights – will enhance productivity. For instance, incentives for improved water productivity can be generated through the establishment of private property rights to water and the subsequent formation of a market.

In all cases, productivity enhancements from such improvements in capital stocks can be achieved for both economic and environmental goods and services. Research and development can be directed to economic good production and/or environmental damage prevention/repair. Technological improvements in manufactured capital can be aimed at improving environmental management and/or economic growth. Property rights can be better defined and defended over growth and/or conservation outcomes.

Higher levels of economic wealth allow these capital stock enhancements. Greater wealth allows more income to be allocated to education/research endeavours. Greater wealth allows more investment in manufactured capital. Greater wealth allows more income to be used for the establishment and maintenance of organisational structures such as the judiciary, police and the penal system to ensure property right defence and the avoidance of corruption.

Greater wealth is also important in ensuring that these capacity improvements – better supply of capital stocks – are also demanded by society. This is critical because unless changes are driven by the populace, it is unlikely that they will be forthcoming. The important linking factor between wealth and demand for change is knowledge – and necessarily, education. As wealth increases, there is generally an increase in society's demand for education and knowledge. With greater knowledge, information flows and capacity within the general public to assimilate the information comes public interest in the condition of the environment. Such awareness may relate to personal health impacts from environmental degradation right through to concerns for endangered species. With

awareness …along with the financial means … comes demand for change expressed through both the private and public sectors. In the private sector, people become interested in purchasing 'green' goods and services. People look for phosphate free detergents and dolphin safe tuna and sign up to be connected to renewable energy supplies. In the public sector, voters call upon their elected representatives to institute policies that protect environmental public goods and services. They vote for air and water pollution controls, creation or expansion of national parks and regulations to help manage natural resources.

Hence, while increased wealth can be argued to be a necessary condition for a reversal of environmental degradation trends associated with economic development, it is not sufficient. In the policy context, it is therefore important for governments to pursue economic growth and to develop specific strategies to facilitate environmental protection. This is consistent with the Tinbergen Principle of adopting policy measures equal to the number of policy challenges (Tinbergen 1952).

5. Australian Agriculture and the Environment

In order to investigate the correlation between economic development and environmental conditions further, it is instructive to look at the performance of Australia's agricultural sector. In this section, two agricultural industries – cotton and grains - are examined to determine if economic development can be achieved along with improved environmental performance.

5.1 Cotton

The Australian cotton industry produces around three million bales of cotton each year and is grown on over 400,000 hectares of land, predominantly in north west NSW and south west and central Queensland. The cotton industry produces around A$1.5billion annually with 90 per cent of the crop being exported (GHD 2003). The environmental performance of the industry was the subject of considerable adverse commentary, particularly in the 1980s and 1990s, because of its use of endosulfan to control insect pests (CRDC 2005). It was found that run off from irrigated cotton was re-entering water ways, taking with it residual concentrations of the pesticide. Subsequently, fish kills in streams and contaminated beef were related back to these 'spill-overs'.

In response to the public concern expressed subsequent to the dissemination of the knowledge regarding the dangers of endosulfan contamination, the cotton industry took a pro-active position to reduce the environmental impacts of its operation. This can be seen as the industry moving to protect its position prior to the government moving in response to public pressure to enforce change. Over the last decade, the industry has developed and implemented Integrated Pest Management techniques and set out Best Management Practices for its members to adopt (Cotton Australia 2007). BMP initiatives have involved safe chemical handling and storage, tail water recycling (run off from irrigated fields is held back from entering streams for a holding period that allows the toxicity of

endosulfan applications to be exhausted), GPS application systems and weather monitoring for optimal pesticide application. IPM measures include the introduction of beneficial insects (such as lady beetles to control the Heliothesis caterpillar) and the strategic application of pesticides. The industry has funded these schemes – through the imposition of grower levies –to the extent of over A$6m (Cotton Australia 2007).

A key element of IPM in the cotton industry has been the application of innovative biotechnology. Most notably, transgenic cotton varieties have been introduced. Bollgard 11 has been genetically engineered to be resistant to attack from the Heliothesis caterpillar. Its introduction thus reduces farmers' dependence on pesticides, notably endosulfan. Another variety – Roundup Ready – has been engineered to be resistant to herbicide application. Its use reduces the need for cultivation and herbicides.

As a total package, BMP, IPM and the introduction of genetically modified varieties have had a number of key impacts on both cotton production and the condition of the associated environment (Macarthur Agribusiness 2004). First, there have been dramatic decreases in insecticide use in the industry (CRDC 2005). From an average of 11 kg active ingredient (a.i.)/ha insecticide in 1998/99, use rates have fallen to less than 0.5 kg a.i./ha. As a consequence, concentrations of endosulfans in water ways have also decreased. For instance, in the Namoi River in north west NSW, endosulfan concentrations have fallen from 0.17μg/L in 1991/92 to zero onwards from 1999/00. No cattle endosulfan contamination incidents have been recorded in the region since 1998.

As these environmental improvements have been achieved, cotton yields have also been steadily growing (CRDC 2005). In the early 1960s, cotton lint yields were less than 200 kg per hectare. By 2002, this yield figure had risen to over 1,700 kg per hectare, more than an eight fold increase over a forty year time span. These productivity increases have been the result of many different factors. They include the introduction of BMP and IPM strategies which can be viewed as the result of human capital injections but also innovations in the manufactured capital used. The processes introduced have effectively allowed a shifting outward of the production possibility function. This in turn has come about as a result of factors relating to increasing levels of wealth in the Australian community – both through increased demands for the environmental improvements to be made and an expanded capacity to make the investments necessary to achieve the changes.

5.2 Grains

Broad acre grain growing occurs across the inland east, south east and south west regions of Australia. The major winter crops are wheat, barley, oats and canola. In summer, the predominant crop is sorghum. Around 20 million hectares of land is cultivated for grain crops each year and production is valued at A$7.6 billion gross per annum (BRS 2007). A key environmental issue facing the industry has been soil erosion brought about by the traditional farming system that involved fallow, cultivation and stubble burning, frequently in conjunction with heavy livestock grazing pressure. Other concerns have

been the leaching of fertilisers into water ways, the degradation of soils through salinisation, compaction and carbon depletion and excessive fossil fuel usage.

Numerous technological changes have occurred in the grains industry over the past twenty years. Most notably, the practice of zero tillage has become widely adopted. Under zero tillage, soil preparation involves the application of herbicide prior to the direct drilling of the seed. Projections suggest that by 2020, over 90 per cent of the area of land under broad acre cropping will be zero till compared to a 10 per cent adoption rate in 1985 (Scott and Farquharson 2004). Without the need to disturb the soil for weed control, there is less opportunity for soil erosion.

Other farming system innovations have further improved soil retention and enhanced soil health. These include stubble retention, crop rotation including nitrogen-fixing plants, soil testing to target fertiliser application and precision (GPS guided) traffic control. These technologies have contributed to improved water use efficiency, thereby reducing the prospects of soil salinisation; reduced levels of nitrogen and phosphorous in leachates and hence improved waterway health; and reduced diesel fuel use. While in 1990, the average fuel use per hectare in grain production was in the order of 11 litres per hectare, by 2005 that figure had dropped to around five litres per hectare. Over the past 15 years, that reduction in diesel fuel use equates to a cumulative reduction in CO_2 emissions of around five million tonnes (Grains Council of Australia undated).

These technological and management improvements have resulted in clear improvements in the environmental conditions in grain growing areas. Water way health has improved both in terms of reduced sediment and nutrient loads and soil health has improved. Malinda (1995) shows that no till and stubble retention strategies reduce soil loss by up to 94 per cent compared to traditional cultivation and stubble burning practices. Scott and Farquharson (2004) estimate that these innovations resulted in 18 million tonnes per annum of soil being retained on farm in the northern NSW grain growing areas.

However, it must be noted that the changes in farming systems were not largely driven by environmental concerns. Rather, the environmental improvements have come about in tandem with remarkable improvements in cropping yields and associated enterprise profitability. Umbers (2007) plots wheat yields on Australian farms over the period 1860 through to the present day. He shows that through the late 1800s, yields declined by 50 per cent (from around 0.8 tonnes per hectare to around 0.4 tonnes per hectare) as the natural resource base was run down. However, over the course of the 20th century, yields have risen to almost 2 tonnes per hectare. This continual rise over that time period was initially the result of the application of super phosphate fertiliser, then because of the introduction of sub-clovers to fix nitrogen in the fallow period, but finally because of the introduction of no till, stubble retention, canola fallow and precision application of nitrogen fertiliser (in solid, liquid and gaseous form) based farming systems. Another key element has been the productivity enhancements due to improved plant breeding. Similarly, Mullen and Crean (2007) observe a three fold increase in total factor productivity in Australian broad acre farming over the period 1953 to 2004.

What this means for individual farmers is an improvement in net returns. Scott and Farquharson (2004) found that up to 2002, the adoption of zero or reduced tillage farming systems generated a net economic benefit to grain growers in northern NSW of up to A$205m and when projected through to adoption rates for 2020, the gains were up to A$568m.

In the case of grains in Australia, the additional capital that has been applied to the industry – in the form of manufactured capital (complex and ever evolving farm machinery) and human capital (research and development as well as farm management) – has been stimulated largely by economic gain. However, these economic gains have been enjoyed because of the realisation that the farming system best suited to the unique Australian environment provides both economic and environmental gains. What has occurred in the Australian grains industry has been a shift from farming systems that had their origins in European agriculture to ones that are specifically adapted to Australian conditions. The consequential shift in the production possibility frontier has allowed win-win outcomes to be enjoyed. More importantly, the observed changes have arisen because the wealth of the nation has afforded the injection of capital, both in terms of the machinery component but also the research and development effort and the capacity of farmers to implement the changes.

The grains case study thus provides evidence to support both the shifting production possibility frontier and the Environmental Kuznets Curve hypotheses.

6. Work in Progress

The preceding analyses of Australia's cotton and grains industries should not be taken to suggest that problems associated with agriculture's impacts on the environment have all been solved. There remain a number of critical interactions where environmental deterioration is problematic. Perhaps the most significant of these involves the use of water for irrigated agriculture. Extractions from rivers that have been regulated through the construction of engineering structures such as dams, weirs and canals to supply crops ranging from rice to grapes to citrus and pastures for livestock have had adverse effects on river health. The irrigation extractions have resulted in reduced overall flow levels and have changed the pattern of flows so that river dependent species of flora and fauna are threatened. Deterioration in water quality and quantity has also impacted negatively on recreational opportunities and the availability of downstream domestic water supplies.

The situation is, therefore, one of economic development with consequential environmental degradation. The trade-offs depicted by the production possibility frontier and the negatively sloped portion of the Environmental Kuznets Curve are in evidence. This is despite technological advances that have been made in irrigated agriculture. For instance, laser levelling of irrigated cropping areas, the development of centre pivot irrigation technology, soil moisture monitoring and drip supply have all resulted in water productivity improvements. The problem with these improvements is that they have been targeted to economic development goals – increasing irrigated agricultural outputs –

without reducing the overall amounts of water extracted from the river systems. Put simply, water savings generated from the technological advances have been put to use in growing more crops.

What is required to redress this situation is a further injection of capital, but in the form of social capital to allow the establishment of well-functioning water markets. The decline in river health has occurred because the environmental values of rivers have not been appropriately recognised in the institutional structures set up to coordinate water use.

A century ago, the environmental values of Australia's river system were not an issue because they were well supplied and few had an interest in them. Indeed, water was deemed to be a major element in the economic development of inland Australia and so was supplied at highly subsidised prices. Institutional structures were developed to encourage irrigation uses. As irrigation extractions increased through time, river health declined. At the same time, people's interest in the environment has increased – with growing wealth and hence education and knowledge. But the scarcity of environmental functions of rivers has not been realised until recently and institutional structures (social capital) have been only slowly developed to ensure adequate supply.

Progress is underway toward the establishment of a system that will encourage the protection of river health and the productivity of irrigated agriculture (Bennett 2006). First, property rights to water have been established so that markets can function as devices to allocate the scarce water resources between competing users – including agricultural, domestic and industrial – through the formation of competitive prices. As prices have risen with growing scarcity, agricultural water users have sought to introduce more water efficient technologies. This explains the development of drip and centre pivot irrigation systems. Second, because environmental values for water will not generally be expressed as market demands, governments, at the behest of an increasingly agitated voting public, have stepped in to enforce 'environmental flows' in river systems. These flows are designed to provide for the environmental health of the river systems.

While this framework for water allocation is now well established in most irrigation dependent regions of Australia, its operation has yet to yield returns. Such has been the extent to which the water resource has been over allocated to extractive uses, that existing environmental flows are being re-assessed as inadequate. Governments are thus faced with the situation of having allocated water rights to irrigators that are in excess of what has been deemed to be acceptable for the environmental health of rivers. Funds are now being allocated for government agencies to enter water markets to buy back entitlements from irrigators. The volumes of water under discussion are not trivial with average allocations in the Murray River system in south east Australia being reduced by between 500 and 800 GL per annum.

With such reductions in water availability, it is highly likely that a movement along the economic development/environmental protection production possibility frontier will occur in the short term. Put simply, some farm driven wealth will be sacrificed for an

environmental improvement in Australian rivers. What policy makers are keen to find are ways in which technological change can be harnessed to push the frontier outwards so that farmers will, in the longer term, be able to re-establish their levels of wealth. Investments in manufactured capital are being sought. For instance, the lining of irrigation supply channels or their replacement by pipes to avoid water supply losses through evaporation and seepage is under investigation, as are further developments in on-farm irrigation efficiency.

A key factor in the government's capacity to undertake these quite dramatic changes in water resource management is the wealth of society. Payments for investments in technological change and payments to compensate farmers for water entitlements sold (in other words, payments to purchase environmental flow water) require savings to be available from the overall operation of the economy. Wealth is the conduit for change. In some ways it may be argued that the wealth generated by irrigated agriculture is now being used to pay for the environmental damage created. However, it is also the case that the institutional framework now being established – a framework that centres on well defined and defended property rights for the water that formerly was (almost) a free good – will provide for the on-going development of processes that will shift the production possibility frontier outwards. Following the logic of the Environmental Kuznets Curve, real environmental improvements will be made achievable by the wealth of the nation.

7. Conclusions

The contention put forward in this paper is that economic development and environmental protection are not necessarily mutually exclusive. It is supported by the logic of two concepts that seek to establish links between the economy and the environment. The first, represented by the production possibility frontier, suggests that for a given set of capital at a specific point in time, a negative relationship exists between development and protection but that over time and with changing levels of capital being applied, an outward shifting production possibility frontier can provide improved economic development and environmental protection. The second conceptual framework, represented by the Environmental Kuznets Curve, suggests that after a certain threshold point, increases in economic development will be associated with better environmental outcomes.

Empirical evidence of relevance to the contention is mixed. While trends in economic growth are clearly positive for Australia, some broad scale environmental indicators show improvements while others show deterioration. To understand the situation more completely, two case studies from Australia's agricultural sector are examined: cotton and broad acre grains. Both examples illustrate the mechanisms by which economic development can precipitate environmental improvement but both also show that economic development is a necessary but not sufficient condition for environmental improvement. A third case study, involving water resource management in rural Australia further illustrates the point that deliberate policy measures are necessary to achieve environmental improvements that are made possible and motivated by increased levels of

societal wealth. Specifically in the case of water in Australia, the establishment of enhanced social capital – in the form of institutional arrangements necessary for the formation of a well operating market – is the key to future improvements in both environmental and economic outcomes.

A key conclusion from this discussion is that policy directed toward environmental protection needs to be wary of driving negative outcomes for economic development as unintended consequences. In particular, policies that depress economic activity will not necessarily be environmentally friendly. What this paper has shown is that reductions in the wealth of a society can take away both the motivation for environmental improvement and the capacity to generate conservation outcomes. Rather, policy makers should direct their attention to the formulation of policies that stimulate economic growth and other, separate policies that target environmental improvements.

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