Assessing the Impact of Rising Petroleum Prices on Agricultural Production in Rural and Regional Australia

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Abstract
This paper reports on the first phase of a three-year research project funded by Land and Water Australia to examine the social and economic vulnerability of rural landscapes and industries to impacts from rising petroleum prices. A key aspect of this project involves creating an ‘oil vulnerability’ assessment index. Rural and regional areas are potentially highly exposed to the impacts of rising fuel costs due to the costs of production and reliance on petroleum dependent transportation networks for access to broader business, community and social services. The paper will review the current high global oil price uncertainty and the ongoing government, industry and public concern about the future cost of petroleum-based transport fuels.
Introduction

Modern agriculture is heavily dependent on petroleum products for fuel, fertilizer and pest control. For most industries, fossil energy constitutes less than 1 percent of total costs; in contrast, these costs for agriculture range from 10-30 percent. Total Australian agricultural energy use increased on average by 2.3 percent annually over the period 1973/1974 to 2000/2001, most of which was comprised of petroleum consumption, yet real energy intensity declined by only 0.3 percent during this period (Tedesco and Thorpe 2003). Agricultural energy intensity has improved marginally over time but aggregate agricultural petroleum fuel demand continues to expand.

One of the most prominent global economic phenomenon since the mid-2000s has been the marked increase in the international price of petroleum (Figure 1). The price of oil has risen from approximately US$30 per barrel in 2003 to over US$140 per barrel in 2008. Long-term oil prices remain uncertain. Many authoritative analyses suggest global oil prices will continue to rise over the medium and longer term (Campbell 2003; Heinberg 2004). This strong price growth recalls the oil crises of the 1970s and increasingly contrasts with the pattern of prices over the last two decades.

![Figure 1: Price of NYMEX Light Sweet Crude Oil, 1997-2006](image)

The reasons for higher fuel prices are multiple, but we can isolate two key factors. First, there has been strong growth in global demand for petroleum particularly from China and India which are undergoing rapid urbanisation and industrialisation. China, for example, has experienced annual GDP growth of 7 per cent since 2000 and 9 per cent since 2003 (International Monetary Fund 2007). Projections from the International Energy Agency (Energy Information Administration 2006) suggest that global demand for petroleum is likely to increase by 40 per cent in coming decades as economic growth and industrialization continue.
Second, this increasing global demand has been met with oil production constraints and an increasingly uncertain global supply future. A number of petroleum observers and commentators suggest that there is an underinvestment in oil production facilities that are necessary to produce sufficient supply to meet future demand (see LeBlond 2005; IEA 2006; Izundu 2008). Some of this underinvestment is due to the increasing concentration of oil reserves in geopolitically risky regions, such as the Middle East, which are increasingly unattractive venues for global investment capital. Another reason for this underinvestment relates to countries spending their oil profits on improving social conditions, rather than on petroleum infrastructure (see Klare 2005).

Further longer term concern surrounds the sustainability of global petroleum reserves. A growing body of commentary and analysis suggests that the world’s petroleum reserves are approaching a point of maximum oil extraction production, after which time declining rates of production will follow (see Hirsch, R., Bezdek, R. et al. (2005) IEA (2007)). While much of this commentary has come from independent sources, there is a growing awareness among governments (see Commission on Oil Independence (2006); Brisbane City Council and Maunsell Australia (2007); Senate Standing Committee on Rural and Regional Affairs and Transport (2007); Queensland Oil Vulnerability Taskforce (2008)) that oil depletion and peak oil are pressing concerns. The United States Government Accountability Office, among others recognise the problem of peak oil and are pressing governments to urgently address the issue of peak oil and plan for its social and environmental impacts.

Problems of insufficient petroleum supply in the face of growing demand imply higher international oil and fuel prices over the long term. Rising fuel costs and an insecure petroleum future raise questions about the challenges agriculture will face in maintaining output. The UN has said that it cannot afford to feed the world and attempting to solve fuel shortage problems through biofuels made from corn is seriously exacerbating food shortages. There has been little concern about the petroleum dependence of agriculture since the oil shocks in 1973 and 1979 because there has been two decades of stable oil prices. As a result only a modest body of research has been undertaken that examines the role of petroleum energy in agriculture and the sensitivity of modern agricultural production to petroleum supply disruptions or rising petroleum costs (see Pimentel 1980). This new petroleum context raises significant questions for rural and regional economies and consequently for natural resources management and policy. In Australia, rural and regional leaseholders play a critical role in land management and if fuel prices begin driving them from the land, government will be forced to step in and take over this role. Anecdotal reports suggest rural households and businesses have been heavily affected by fuel cost impacts on production expenses, transport and commodity demand (Browne 2006).

Energy use in agriculture deserves new attention from researchers for two reasons. First, there have been substantial shifts in the structure of the agricultural sector in the past two decades which have transformed the technological, institutional and market composition. Second, it is expected that agriculture will play a role in supporting growth in energy demand through the production of biofuels, such as ethanol and biodiesel. Biofuel production has important implications for the broader sector and has already stimulated new demand for particular crops, such as grains. Corn prices have increased sharply in the past two years due to new US government subsidies for biofuels and in turn have stimulated new demand for corn-substitutes such as wheat and barley. Rising
food prices have led some observers to declare ‘the end of cheap food’, which will impact considerably on food security programs for the poor, in industrially developed countries, and particularly in developing countries already experiencing serious food shortages. Such dynamics will inevitably affect the agricultural sector in ways that are as yet not well appreciated.

Energy in Agriculture: New Imperatives

Recent attention on energy in agriculture only tangentially addresses two ongoing trends affecting agricultural oil vulnerability in contrary ways: declining farm income, which accentuates vulnerability, and increasing energy efficiency, which mitigates it. Further, these trends have developed so profoundly since the 1970s that the more relevant observations from that era only loosely apply today. Particularly in Australia, a paucity of recent direct observations of energy use in agriculture differentiated by sector, scale and location compounds our uncertainty over the trends affecting farm income and energy efficiency. Below we describe these contrary trends, and conclude with implications for further study of energy and agriculture.

Increasing Energy Costs and Decreasing Profit Margins. The price of petroleum-based agricultural inputs (i.e., energy inputs) in Australian agriculture has increased since the 1970s and particularly since 2000 in real terms as well as relative to other inputs (Figure 2). This relative pricing puts pressure on Australian farmers to substitute petroleum-based inputs with less costly and less energy intensive inputs and practices (e.g., conservation tillage Zinser, Miranowski et al. 1985), particularly in light of trends amongst American competitors towards a scenario in which petroleum-inputs remain relatively cheap (Miranowski 2005: especially Table 3.5) and anticipation that oil prices will remain high. Simultaneously, as in other post-industrial nations, the profit margins of various Australian agricultural sectors have narrowed considerably over recent decades, leaving their producers less able to weather sustained high oil prices or interrupted energy supplies (Table 1). Though the data on declining farm profits presented in Table 1 end in 1996-97, comparable data for 1990-2006 presented in Figure 3 and Figure 4 suggest that Australian farmers continue to struggle with economic pressures. Broadacre and beef enterprise have fared particularly poorly since the rapid increase in the cost energy inputs after 2000 (Figure 2, Figure 3, Figure 4). Declining farm income similarly pressures producers to adopt more economical, less energy intensive operations, though it also leaves them less able to invest in energy-saving measures. The ongoing drought has also afflicted producers severely since 2000, and constitutes an additional constraint and threat to the economic viability of producers. Lower incomes, greater energy costs and climatic stresses mean greater generalized vulnerability for the Australian agriculture sector and suggest that further increases in energy costs will affect farm incomes more severely than in the recent past, as has already been the case since the late 1970s (Table 2).
Figure 2: Increasing Costs of Petroleum-Based and Other Inputs
Australian Wheat and Cropping Sector, 1990-2006,
(Average per Farm in 2005 Dollars)

Source: Australian Bureau of Agricultural and Resource Economics (2007)

Notes: (i) Fertilizer: includes soil conditioners, (ii) Land rent: paid on land rented or leased, (iii) Wage labour: excludes amounts paid to contractors, (iii) Total freight: total freight paid during the survey year on all commodities. N = 276 farms on average annually. Range = 98-376 farms.

Table 1: Average Profit Margin of Farm Businesses

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Grain</td>
<td>36.2</td>
<td>20.6</td>
<td>18.6</td>
<td>29.9</td>
</tr>
<tr>
<td>Grain-Sheep-Beef</td>
<td>--</td>
<td>--</td>
<td>16.3</td>
<td>20.1</td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep-Beef</td>
<td>25</td>
<td>24.9</td>
<td>14.2</td>
<td>17.5</td>
</tr>
<tr>
<td>Sheep</td>
<td>27.9</td>
<td>23.7</td>
<td>12.4</td>
<td>20.9</td>
</tr>
<tr>
<td>Beef</td>
<td>23.6</td>
<td>23.6</td>
<td>20.4</td>
<td>10.8</td>
</tr>
<tr>
<td>Dairy</td>
<td>38.5</td>
<td>28.3</td>
<td>22.9</td>
<td>21.8</td>
</tr>
<tr>
<td>Pigs</td>
<td>12</td>
<td>18.5</td>
<td>16.4</td>
<td>17.3</td>
</tr>
<tr>
<td>Fruit</td>
<td>31.9</td>
<td>23.8</td>
<td>23.5</td>
<td>22.4</td>
</tr>
<tr>
<td>Vegetables</td>
<td>31.4</td>
<td>25.7</td>
<td>--</td>
<td>20.9</td>
</tr>
<tr>
<td>Poultry</td>
<td>18</td>
<td>14.9</td>
<td>15.1</td>
<td>--</td>
</tr>
<tr>
<td>Sugar</td>
<td>--</td>
<td>30.9</td>
<td>29.8</td>
<td>30.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32.8</strong></td>
<td><strong>22.9</strong></td>
<td><strong>17.8</strong></td>
<td><strong>21.7</strong></td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics (1994: Table 4; 1996: Table 3.14; 1998: Section 6)

Notes: (a) Cash operating surplus divided by turnover, expressed as a percent.
Figure 3: Trends in Financial Performance of the Australian Broadacre Sector
(Average per Farm in 2005 Dollars, 1990-2006)

Source: Australian Bureau of Agricultural and Resource Economics (2007)

Notes: Family Share of Farm Income: ownership share of farm income of owner manager, spouse and dependant children; Farm Business Profit: farm cash income plus build-up in trading stocks, less depreciation expense, less the imputed value of the owner manager, partner(s) and family labour; Non Farm Income: total off farm income of the owner manager and spouse including wages and salaries, rent, dividends and interest. Note also the general increase in non-farm income as well as the sudden increase in non-farm income after each decline in farm income. N = 276 farms on average annually. Range = 98-376 farms.

Figure 4: Trends in Financial Performance, Australian Beef Sector
(Average per Farm in 2005 Dollars, 1990-2006)

Source: Australian Bureau of Agricultural and Resource Economics (2007)

Notes: see Figure 3. N = 363 farms on average annually. Range = 266-479 farms.
Table 2: Fuel Costs as a Proportion of Total Farm Costs and Income
(Average per Farm, Australia, 1979-80 and 2005-06)

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>1979-80 % Total Costs</th>
<th>2005-06 % Total Costs</th>
<th>1979-80 % Total Income</th>
<th>2005-06 % Total Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>11.7</td>
<td>6.5</td>
<td>9.5</td>
<td>21.1</td>
</tr>
<tr>
<td>Cropping</td>
<td>12.3</td>
<td>10.4</td>
<td>10.8</td>
<td>32.4</td>
</tr>
<tr>
<td>Dairy</td>
<td>8.5</td>
<td>3.9</td>
<td>26.8</td>
<td>15.4</td>
</tr>
</tbody>
</table>


Notes: Full descriptions of the estimates of farm income and farm costs for 1979 are available in Bureau of Agricultural Economics (1979). For 2005-06, farm income is defined as “total cash income”, or the difference between total cash receipts and total cash costs, which is commensurate with the 1979-80 definition. Farm costs for 2005-06 are defined as “total cash costs”, or the sum of payments made by the farm business for permanent and casual hired labour (excluding operator or manager, partner and family labour), materials, services, produce purchased for resale, livestock purchases and transfers onto the property, interest and payments to sharefarmers, but excluding capital and household expenditures. As cost figures for 1979-80 include depreciation, transportation and freight, fodder, and insurance costs (though exclude livestock purchases), and the 2005-06 estimate do not, the former is likely more inclusive than the later such that the tabled figures likely underestimate the extent to which fuel costs have increased as a proportion of total farm costs.

Increased Energy Efficiency. Increased real energy prices have forced energy efficiency on industrial agriculture globally since the early 1980s. Farmers have switched from inefficient petrol-powered machinery to efficient diesel machinery, adopted energy conserving tillage practises, resized equipment more appropriately and adopted energy saving technology for irrigation, to name but a few (Zinser, Miranowski et al. 1985; Uri and Day 1991; Economic Research Service 1997). The widespread adoption of larger-scale diesel equipment offered producers more horsepower with greater fuel efficiency and cheaper fuel in terms of energy density per dollar. Indirect energy consumption has also become more efficient. Technological innovations reduced the energy requirements of the manufacture of nitrogen and phosphorous fertilizers by 11 percent and 27 percent, respectively, between 1978 and 1987 (Bhat, English et al. 1994; Miranowski 2005). The upshot of such changes is a less energy-intensive agricultural sector relative to that of two decades ago. In the USA between 1978 and 2002 farmers decreased direct energy consumption by 30 percent between and indirect energy consumption by 38 percent in aggregate (Miranowski 2005). American farmers also registered an overall improvement in agricultural energy intensity, i.e., energy consumed per unit output. American data describe a 30 percent decrease in energy consumed per agricultural dollar produced between 1973 and 2002 (Miranowski 2005: Appendix Table 3.15, Figure 3.15, 84) and a two percent per annum increase in total factor productivity, i.e., indexed output per input (Figure 5). Data for the Australian agricultural sector are too aggregate and too poor to reliably describe similar trends (e.g., ABARE 2006), though analysis observes a ‘sectoral contribution’ of 0.6 percent by the Agricultural, Forestry and Fishing sector to the 18 percent overall improvement in Australian economic-industrial energy intensity since 1973 (ABARE 2003: Tables 5 & 6). This indicates suggesting that a parallel energy efficiency trend to that in the US is occurring in Australia.

Agricultural energy efficiency is driven by and counter to trends toward costlier energy. While costlier energy encourages producers to use less energy and energy-intensive inputs, antecedent improvements in energy efficiency make less certain the manner in
which future increases in the price of oil may stress producers, encourage adaptation and accelerate reductions in energy use. Further, improved factor productivity has been achieved far more through progressive increases in agricultural output than through decreases in associated energy inputs (Figure 5). This fact highlights an agricultural oil vulnerability which exists despite greater energy efficiency: as high-yielding cultivars are especially reliant on appreciable energy inputs (as through fertilizer, chemicals, irrigation), even relatively small decreases in energy use may cause disproportionately large declines in farm output and, thus, degeneration in energy efficiency trends. This dynamic would both compound and be compounded by the marginal incomes of farmers.

![Figure 5: Total & Energy Factor Productivity in American Agriculture, 1973-2004](image)


Notes: Total Factor Productivity: ratio of total output index to total input; Energy Factor Productivity: ratio of total output index to averaged combined index of energy and chemical usage; Total Output Index: indexes total agricultural output for all farm types; Total Input Index: indexes all agricultural inputs, such as labour, land, energy, equipment, etc.; Total Energy Input Index: averaged sum of indices for energy and chemical inputs. For fuller definitions see Economic Research Service (2007)

**Summary and Implications**

The preceding sections suggest both a likelihood of adjustment in the agricultural sector to increasing oil prices as well as an uncertainty surrounding such adjustments. This section concludes by summarizing possible adjustments as well as qualifying them in hopes of contributing to an agenda to guide future empirical investigations on energy use in agriculture.

The spatial dimension of agricultural oil vulnerability has been an implicit yet central theme the question of energy in agriculture. To a greater or lesser degree, spatiality underlies the differential vulnerabilities of agricultural sectors, the competition between local markets and supermarkets, and the feasibility of growing low-input biomass in remote marginal lands (which will likely intensify land degradation that always occurs when marginal lands are put into production when there are good markets for grain crops). In Australia, different agricultural sectors having different inherent oil vulnerabilities are highly segregated in geographic bands of intensive ranching, cropping,
mixed grain-livestock and extensive beef operations with declining precipitation and proximity to markets as well as increasing land availability with distance from the capital cities (Figure 6). In such a scenario, conjoint circumstances may ‘conspire’ against a particular sector, increasing its vulnerability, loss and unresponsiveness in the face of increased oil costs. For example, beef operations in Australia are not only inherently vulnerable to increased oil costs due to their limited inputs and outputs but are also subject to drought-prone climates, costly transportation requirements and long distance to market, the latter of which may limit participation in local ‘boutique’ markets and discourage low-input biomass production otherwise favoured by high land availability and limited production options in the periphery. Thus, oil vulnerability may concentrate in certain regions or ‘bands’. High oil prices will probably increase feed lotting of beef and further concentrate agricultural production. This may be problematic because risks from natural hazards (floods, drought, etc.) may become more prevalent in the future. Thus, future studies concerning possible changes to agricultural production due to high fuel costs should consider the impact of natural hazards as well as distance and transportation costs.

Of particular interest may be the ongoing competition and/or division of the market between local markets selling local produce and supermarkets selling long-haul agricultural goods. It remains somewhat uncertain to what degree and how frequently local markets selling local produce do so with lower total energy expenditures relative to supermarkets selling long-haul produce. While energy savings are possible through local production and consumption owing to decreased food miles, it is also true that supermarkets’ mode of transportation is increasingly streamlined and offers economies of scale that yield energy efficiencies beyond the capabilities of multitudinous locally-orientated producers, leading some to comment that supermarkets, and not local producers, optimally utilize energy. Further research might clarify the energy-efficiency advantage of local relative to supermarket-orientated agriculture, and determine to what extent this is reflected in lower prices and easy access to attract consumers and grow market share. Also, as the local-versus-distant dynamic intensifies with increasing energy costs, further research might also describe the structural adaptations made in the locally-orientated agricultural sector (e.g., consolidation, regionalization) in order to gain efficiency and better compete with supermarkets. Thus, signalling fundamental changes in how agriculture is organized. The role of supermarkets and their increasing influence as a result of oil vulnerabilities deserves a paper on its own.
The metrics of ‘energy efficiency’ or ‘energy intensity’ alone are often inadequate as harbingers of agricultural change. Studies concerning energy ratios and food miles may neglect the fact that the most cost effective process is not necessarily the most energy efficient but may still take precedent, particularly as it likely best reduces a producer’s generalized vulnerability. Approaches that neglect the economics of a producer’s alternatives to favour energy will produce partial insights at best and useless policy at worst. ‘Economics’, however, is not limited to farm income or other monetary issues but may also deal with land requirements, labour, time demands, seasonality, complementarity, risk and so on. The choice between high versus low-input production systems to produce food as well as biomass for biofuel provides a clear example. On the basis of energy efficiency alone, the low-input biomass production systems are favoured over high-input systems. However, low-input systems also require many times more land than high-input systems to produce the same quantity of energy and/or food. Upon considering land requirements and limits relative energy efficiency and a given demand for food and biomass, the less efficient high-input system actually produces more energy overall (see Nonhebel 2002 section 4.3 and ; Nonhebel 2008 for calculations). Further studies may gain rare insights into (un)changing energy use in agriculture by simultaneously considering factors that complement and contrast energy-efficiency.
metrics, e.g., energy-use per unit of production and cost-efficiency of production. In this respect, there are few analytical approaches better suited to illuminate our ignorance of changing energy use in agriculture than case studies that control for a variety of factors as they influence the ‘optimal’ as well as actual dynamic of energy use.

Planning Implications

Agriculture is a hugely significant land use in Australia because of the vast spatial scale of agricultural activities. The economic viability of agricultural land uses has important implications for regional environmental, landscape, economic and cultural systems. This is not solely a regional question – agricultural activities abut or are intermeshed with most Australian urban centres especially within the peri-urban zone (Low Choy et al 2008). A major change in the global petroleum environment could therefore have large implications for spatial land-use planning. Our research is only at the initial investigative phase but the planning implications of higher global fuel prices could include the following: changes to the distribution of agricultural types within Australia’s regions; changes to the intensities of agricultural land uses; shifts in the primary mode of transportation of agricultural products, such as from road to rail, restructuring of settlement patterns – concentration or dispersal – as communities adapt to higher transport costs; abandonment of some land types or sub-regions if production and transport costs became prohibitive.

Many of these potential changes would require a response from planning. This might include managing the impacts of changing agricultural land uses, ensuring resource availability and conservation, or addressing shifting transport demand through network and infrastructure development. Significant changes in settlement hierarchies and patterns could alter the economic and social structure of regions and in turn contribute to new environmental management challenges. At present the type, range and scale of future responses to the impacts on agriculture of higher global fuel prices are highly uncertain, not least because there is a dearth of contemporary research into either the role of energy in sustaining agricultural systems or into the likely planning challenges emerging from the intersection of higher fuel costs and agricultural processes. This research signals an initial engagement with these emerging issues.

Future Directions

The next phase of this research involves developing a methodology to support regional and rural economic, social and land management policy by mapping regional exposure to strategic oil risks and by informing and aiding industry and government responses. This will involve combining a transport accessibility model with an agricultural production unit model to produce a detailed spatial representation of fuel consumption, price sensitivities and demand elasticities. The model will provide a key tool to assess the oil vulnerability of rural and regional agri- and eco-tourism sectors. Secondary natural resource impact resulting from production shifts/conversions, settlement restructuring and environmental constraints will also be assessed. The knowledge generated by this research is intended to aid industry and governments in managing the impacts of rising fuel prices on rural and regional areas by providing geographically targeted and timely policy interventions.

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