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Author: Anthony Sorensen

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Imagining the Spatial Future of Australian Agriculture

Anthony Sorensen
University of New England
Madgwick, Australia
asorense@une.edu.au

"Rejoice in the things that are present; all else is beyond thee."
(Michel de Montaigne, 1533-1592, Essais)

"Some things always are, without ever becoming; some things become, without ever being."
(Plato, 424-348 BC, Timaeus)

Abstract

It appears likely that Australian agriculture will be transformed hugely over the next decade driven by the same factors shaping the nation's current mining boom. Experience tells us that fast economic development is universally accompanied by rising per capita consumption of food and fibre, and demand for higher quality, more diverse and year round produce. Perched on the edge of over 40% of the world's population, living in an arc from East to South Asia, and recording GDP growth rates averaging 7% per annum, Australia's farm sector will be a major beneficiary. This furious pace of Asian development, combined with (a) rapid domestic corporatisation of the countryside, (b) substantial changes in internal policy settings affecting the farm sector, and (c) inward investment from Asian multinationals, will wreak immense changes in what is produced where and how. We conceptualise the processes at work and develop a likely downstream production scenario very different to current spatial patterns.

Keywords: Australian agriculture, mid-range forecasting, Asian demand, corporatisation of production, foreign investment

1.0 Introduction

This article reflects the confluence of several personal interests. First, the author was recently involved in a rural forecasting exercise, which was part of a consultancy for Australia's Cotton Cooperative Research Centre on innovative small business in cotton-growing communities. That work, in turn, grew out of a long-term interest in spatial forecasting, especially using scenario development (see, for example, Sorensen, 2007). Thirdly, the author has an abiding interest in Australia's rural development from the perspectives of an economic libertarian. Connected with that, he has a deep awareness of contemporary economic processes (macro- and micro-) through running a superannuation fund heavily invested in Australian equities.

This background informs the article's three main aims. It seeks to understand the monumental forces now shaping Australian agriculture and its surrounding service sector, firstly at a global scale and secondarily in a domestic context. We will subsequently assess which of those forces have the greatest capacity to modify the current agricultural landscape. This finally leads to an exploration of

potential regional consequences where those changes do take effect over the nearly 40 years to 2050. One can skate only lightly over this cosmic agenda, but it is an important task given my conviction that the forces currently shaping Australian rural economy and society will not only be among the most dramatic ever witnessed in a developed economy, but also can be readily absorbed by its participant individuals, corporations and governance system. It could also trigger self-reflection on the part of many geographers about the tsunami of change about to sweep rural economies and societies globally and their preparedness to confront them. For instance, a recent report from Australia's Department of Agriculture, Fisheries and Forestry (DAFF, 2012) claims that Australia's agricultural output could more than double by 2040 and raise the sector's share of the economy from 2% to almost 5%, overtaking manufacturing's share in the process! These dynamics imply important lessons about the qualities required of adaptable economies and societies.

2.0 Global Background

This paper examines the processes at work globally shaping agricultural futures. This big picture is crucial for Australia, which produces food and fibre for over 60 million people. Given a domestic population of 22 million, Australia has to export roughly two thirds of its agricultural output into global markets corrupted by subsidies and other forms of protection. Agriculture was one of the great, and still unresolved, sticking points in the WTO's Doha round of trade liberalisation[1]. Let us therefore examine separately evolving supply and demand conditions for both food and fibre. On the demand side, the United Nations (2007) has estimated that he world's ageing population will increase from 7 to a little over 9 billion by 2050 (+28.5%). Apart from these crude numbers, the rising proportion of adults in the population brought about by a combination of declining fertility rates in many countries and rising life expectancy will also boost food and fibre consumption. Many parts of East and South Asia (e.g., China, India, Indonesia, Thailand, and Vietnam) are experiencing unprecedented GDP growth averaging perhaps 7% per annum, and China's gross GDP will exceed that of the US over the next decade. Collectively these countries are home to over 2.5 billion inhabitants, or over 1/3rd of humanity. Since at least the start of the industrial revolution in around 1750, rising wealth has been accompanied by rising per capita food and fibre intake. Wealth enables a greater volume of consumption, reciprocally reinforced by people's steadily increasing average height and girth (Grigg, 1994). Moreover, industrialisation stimulates demand in other profound ways. Apart from quantity, rising wealth triggers demand for a rising diversity of food intake, greater quality in terms of freshness and appearance, and aseasonal supply—the suspension of seasonal rhythms in favour of year-round availability (Schmidhuber & Shetty, 2005).

Suppose that average per capita food consumption in rapidly developing and poor countries, which currently contain about 2/3rds of humanity, rises by 30% over the period to 2050 from all these causes, plus increased likelihood of wastage from, for example, long-distance haulage and a higher incidence of eating out. Suppose, too, that consumption in developed economies keeps to current per capita levels. If the population in developed countries rises on average at 0.5% per annum and the rest of humanity averages 0.9%, we can estimate that total food and fibre consumption will rise 57% by 2050. This back of the envelope calculation is greatly exceeded by some other estimates from

[1] See http://www.wto.org/english/news_e/news11_e/tnc_dg_infstat_29apr11_e.htm for a detailed analysis of the problems encountered.

official sources. Both the UN FAO (2009) and DAFF (2012) have forecast demand growth for food and fibre of 70% and 75% respectively. These estimates ignore the possible conversion of crops into ethanol and other products. However, other estimates put food production at sufficient for 10 billion people, and the problem is not production, but various kinds of wastage. See, for example, Pearce (2011).

Whereas demand looks like a one-way upward street, supply is beholden to a complex array of interacting opportunities and threats, none of which are immutable. We have limited supply of additional agricultural land. Indeed, the area of agricultural land will increasingly, in all likelihood, be constrained by urbanisation, mandated environmental conservation (including its enforcement), and possible water shortages. Moreover, there is a prospect of restrained growth in agricultural productivity. The FAO has drawn attention to flagging agricultural research and development and called for a new green revolution to revive faltering productivity growth in many countries and restraining ability to supply latent demand (Alston et al., 2009). Environmental conservation restrictions will grow on land clearing, surface water storage, extraction of water from aquifers, and activities which reduce biodiversity. Climate change, insofar as global warming continues, is likely to capriciously enhance or impede agricultural production depending on location. Much of current production globally is distorted by agricultural subsidy regimes. Subsidies undoubtedly help inflate production in nations or regions where they apply, but often depress production elsewhere (Costa et al, 2009). Subsidies are high in the US (28% of Gross Value of Production), EU (32%), and Japan (60%), but negligible in Australia and New Zealand (ca. 5%). The extent of impact is often spatially variable depending on the nature of recipients. In Europe and Japan, many of the recipients are small-scale producers and subsidies serve to keep them on the land, but marginal producers often lack the capital and scale economies necessary to maximise output (Bryden et al, 2011). In the US, many subsidy recipients are corporations who simply pocket subsidies as increased profit on output that would have occurred anyway (Kirwan, 2007). So subsidies are unlikely to help meet latent demand by 2050, and the required outcome can be achieved by other means. Subsidies are everywhere an ideological response to issues like (i) protection for smaller and less-productive farmers, (ii) fears about food security (or, more recently, the dangerous idea of food self-sufficiency), and (iii) willingness to pay up big-time for regional equity.

Supply is also dependent on several dimensions of international finance. Movements in relative exchange rates can raise or destroy farm income. The availability of capital can impact on critical investment decisions, including (a) use of latest technologies or equipment; (b) increasing vital economies of scale; (c) diversification of operations over commodities or geographical regions; (d) surviving fluctuating climatic conditions (prevalent in Australia); or (e) use of environmental remediation. The collective internal decisions of trading blocks, whose operations are designed to protect, partially or wholly, insiders from external competitors, can tilt decisions about farm operations in favour or against additional output. And finally, global trade relations (for example, greater freedom of global agricultural trade post – Doha) might lower the cost of food for many consumers and paradoxically increase food insecurity for some.

Reforming the structure of farm enterprises could also be crucial in raising supply. Agriculture is often more like a cottage industry when compared with most industry sectors – more like a corner store compared with a supermarket. Where are the $160 billion agribusinesses to compare with mining giants like BHP? The arrival of capital-intensive corporate agriculture could dramatically

increase supplies of low-cost food and fibre and this is happening fast in some places, especially Australia where bidding wars for assets are emerging. Although 27% of Australia's production comes from corporate farms, they still account for only 2% of farm enterprises – or about 2368 in total, which suggests that farm consolidation will rise sharply in years ahead as small players exit the industry (Neil Clark & Associates, 2011). If supply constraints force up food prices relative to latent demand, the normal market response is to increase supply. Agriculture is not exempt from this rule, but its capacity to respond quickly to shortages and associated price signals can be quite heavily lagged by seasonal conditions, length of growing period and difficulties in switching commodities. However, it is probable that large corporations with their more ready access to capital and expertise can adapt more flexibly to changing patterns of demand. Given everything else said thus far, the prognosis for food and fibre prices is upward, especially with the increasing diversion of food to bio-fuels production. On the down-side, the development of cyanobacteria industries could halt the use of food for ethanol at a stroke (Jabr, 2011).

This leads us nicely into the relevance of technology for increasing agricultural output. In the absence of everything else reported here, new and improved technologies of most kinds will dramatically affect kind, quality, form, efficiency and profitability of agricultural production, often in rapid and completely unanticipated ways. Potential technologies include: (i) the addition of native crop and fruit species to the range of commercial commodities; (ii) genetic modification of plant and animal species to better withstand a range of adverse environmental conditions effectively and efficiently; (iii) on-going refinement of irrigation technologies to reduce water needs per unit volume of production and avoid environmental harm; (iv) improving soil management through new tillage systems and the more targeted application of fertilisers; (v) better management or eradication of animal and plant diseases; (vi) further application of GPS and IT systems to farming; (vii) development of specialized machinery to handle any of the stages in agricultural production and distribution; (viii) application of renewable energy technologies to increasingly energy-dependent modern farm enterprises—even to the extent that each farm, and especially the larger capital-intensive operations, become self-sufficient in electricity and liquid fuels; (ix) anything to do with commodity logistics (handling and distribution to market); (x) improved application of expert systems to select the most profitable combination of quantities of various commodities to produce under expected market and environmental conditions; and (xi) honing farm management systems to reflect best business practices, with the aim of maximising the returns from inputs while simultaneously creating innovative, flexible and adaptable enterprises.

In conclusion, just about all aspects of commodity demand and supply are on the imminent cusp of massive changes affecting the whole spectrum of agriculture from the industrialised pole to native self-sufficiency.

3.0 The Perils of Forecasting

It is worthwhile standing back a moment and considering how all the above factors might combine to shape the future of agriculture. In full scenario modelling (Schwarz, 1996), one would need to explore:

a) The range of possible settings for each variable
b) The probabilities of such settings occurring
c) The way they integrate / interact with each other, and
d) Possible unusual events. There are many options here: climatic change; food security scares leading to rising protectionism; spikes in energy

(oil) prices; tipping point scenarios—especially severe on agriculture, forestry, fishing; and economic warfare over access to scarce resources (including fresh water).

In effect, one would seek to integrate all the factors influencing the future of agriculture generally. This is a massive task because of the large number of variables typically used in such exercises. My unpublished consultant's work for the Cotton CRC identified 60+ variables, as did earlier forecasts for Australia's Department of Immigration (Sorensen, 2007). To consider just the first-round effects between all possible pairs of 60 variables, we are looking at 1770 possible one-way connections $(60^2 - 60) / 2$. If we add in second- and third-round effects, we are looking at a cosmic number of inter-variable links. The task would be further complicated if we were to recognise the relative strengths of each variable and the dominant direction of influence between each pair.

The forecaster should also be worried by endemic and exponentially rising uncertainty in global economic settings, all aspects of farm management and production technologies and related environmental conditions (e.g. global climate change). Sorensen (2011b) identified numerous mutually interacting dimensions of uncertainty of the kinds shown in Table 1, which melds Quantum Mechanics, Chaos Theory, Complexity Theory, Tipping Point Theory, Information Deficiency (quantity, quality and usability), Governance Theory, and Socionomics. Taken together, these considerations may just about throttle any prospect of accurate forecasting, but that in itself is no reason not to speculate on possible courses of events since *future imagination* is a core component of any flexible and adaptable society (Sorensen, 2011b).

4.0 A Snapshot of the Australian Economy and Primary Industries' Role in it

Global forces are often modified to a degree by national circumstance and this is undoubtedly so in Australia whose circumstances tend to differ from many other parts of the developed world. To start with, Australia has a tiny population of just 22 million people occupying an area the size of the continental US and consequently possesses sparse population density outside of the major coastal cities. Its population growth has also powered along at up to 2.5% in recent years, mostly on the back of skilled immigration, with the consequence that the estimated 2050 population is now put at 36 million (+53%) according to Treasury's Third Intergenerational Report (Australian Treasury, 2010). Most of those migrants are destined for large city employment, or at least residence. Unusual for a developed nation, a large portion of the country is either tropical (occupying the equivalent of Africa's Sahel belt or what Holmes (2002) terms the rangelands) or desert (though a little more vegetated than the Sahara).

Table 1: *Fifteen Sources of Economic Uncertainty*

#	Theory	Item	Impact on Uncertainty
1	**Quantum Mechanics (QM)**	The social science equivalent of Heisenberg's uncertainty principle in Quantum Mechanics	All economic actors and agents can be regarded as economic quanta (EQ). All EQ exist in wave form (cycles) and have different velocities, which makes it difficult to state their exact position in economic space

2		Unknown and/or unknowable interactions between Economic Quanta in time and space	It follows from #1 that it is difficult to define how EQ are likely to interact with each other in time and space. For example, supply and demand interactions are likely to be in imperfect equilibrium, if at all
3		Superposition of economic events (like scientific discovery or its application) in simultaneous multiple locations (also a QM analogy)	Key economic events like innovation often appear simultaneously in different locations with highly uncertain competitive effects
4		Entanglement (also a QM analogy)	Event A in region B alters the latter's economic settings and dynamics (C), but also has simultaneous and unknowable impacts on region D (Example: the contagion of the Global Financial Crisis)
5		Decoherence (also a QM analogy)	Entropic (disordering) effects arising from the decay of an economic activity into its environment. This effect is pervasive on account of changing environments (e.g. resource depletion) or emanation of new competitors or technologies
6	**Chaos Theory**	High leverage of A on B (cf. Chaos Theory)	Small events may leverage large effects through some combination of (a) numerous and/or rapidly acting feedback loops, (b) exponential leveraging effects, (c) effective networking, (d) changing spatial comparative advantage
7	**Complexity Theory**	The increasing number of variables shaping economic events, with large numbers of often unknown feedback loops (cf. Complexity Theory)	Economic systems typically comprise many more operational variables than physical systems (QM), with shifting relative importance (and form) of the variables and their mutual links over short time-spans
8	**Tipping Point Theory**	Unknown, but strong and latent, system destabilisation (cf. Tipping Point Theory)	Like all ecologies, implicit system stability may betray rotten foundations which can suddenly give way to over-turn the established order
9	**Information Deficiency**	Poor information about (A) individual variables, (B) particular economic actors (EQ), or (C) systemic links between them	The lack of regularity in EQ (unlike say particles of light) imposes great analytical constraints
10	**Governance Theory**	Frequent system recalibration by governments and regulators	These actors frequently amend taxation and interest rates, money supply, reporting obligations / standards, trade links, and so on, each change potentially having large-scale effects

11	**Socionomic Theory**	Fluctuating economic psychology	The behaviours and mood-swings of individual and collective actors can be huge, often unanticipated and sudden, and excessive relative to market-place fundamentals
12		The accelerating pace of change in items 1-11	Basically, all system dimensions are not only becoming more complex, but the pace of change in system construction is becoming faster. Lagging (shortening) speed of considered response to changing stimulae may increase (decrease) decision-making error
13		Uncontrollable compounding effects periodically generate system - wide crises	Crises are inherently self-correcting in market economies, but the speed and extent of correction typically reveal dramatically different micro-regional effects
14		Prism of regional resilience & adaptive capacity	Extent of regional resilience to regional shocks will tend to be inverse to quality of the 5 capitals
15	**Chaos Theory (again)**	Other compounding effects	Many of these uncertainty dimensions will interact with others to increase general levels of uncertainty. The extent of this leveraging probably increases exponentially into the future. Included here is regional ability to enhance and maintain the quality of their 5 capitals or alternatively compete for available resources

Source: The Author

Moreover, its economy is largely resource-based. Agriculture and mining account for about 75% of all exports (ABS, 2011a). That said, the productivity of both resource sectors is world-class. *Direct* employment in the two sectors combined is about 4.7% of the total (ABS, 2011b), but they contribute a massive 12% of national value added (ABS 2011c) or roughly 2.5 times the national average product per capita. Investment in mining has reached phenomenal proportions and, as of April 2011, the capital value of advanced mineral and energy projects under construction in Australia—including infrastructure—was estimated at $A173.5 billion (ABARES, 2011). Compare this with the A$150 billion bail-out of Greece in May 2010 by the Euro-zone and IMF.

Up to 2005, agriculture had the best track record in Total Factor Productivity (TFP) growth of any industry sector over the previous 25 years, averaging 2.5% per annum. Central to this was a focus on high quality research and development coupled with the sector's rapid up-take of innovation (Productivity Commission, 2005; Sorensen, 2011a). However, agricultural research and development fell from 8.6% of national outlays in 1996-97 to 5.6% in 2006-07 (ABARE, 2009). TFP could, of course, be enhanced again by further farm amalgamation. Perhaps even more surprisingly, mining and agriculture receive only minimal public subsidy, almost nil for the former, and only around 5% of the gross value of production for the latter. Arguably, though, the absence of the deadweight of support has forced agriculture in particular to be highly adaptive to change. Indeed, Australia ranks third on the Heritage Foundation's Index of Global Economic Freedom behind Hong Kong and Singapore. More than most, the nation is essentially a fairly pure market economy. Manufacturing was a paltry 9% of total value added and utilities and construction added a further 10%. The remaining 69% of the workforce is in the service sector, one of the highest

proportions in the world, and paradoxically Australia is also one of the most urbanised of nations (90%), indeed far more so than most European countries, Canada and the US.

Australia was also substantially untouched by the Global Financial Crisis (GFC) because governments, both Federal and State, had no national debt coupled with highly competent financial regulation designed to cap asset bubbles. There was no technical recession, and after briefly rising in 2009, unemployment has now fallen to a little more than 5%. Strangely, too, the nation's wealthiest regions are now increasingly rural and not urban. This may not have happened anywhere in the world during the last 400 years, possibly to the discomfort of Richard Florida (2002).

Crucially, Australia no longer finds itself geographically remote. It is adjacent to numerous fast-growing Asian countries, including China, India, Indonesia, Vietnam and Malaysia, all of which are eager for resources. Australia's trade is rapidly reorienting to such countries. In April 1991 those five countries took nearly 8% of Australia's exports; twenty years later their share was over one-third (36%) of a much larger export income that had risen 2.5 times in real terms (ABS, 2011a). Based on this export performance, the value of one Australian dollar has risen from US$ 0.52 to US$ 1.06 (x 2.03) and—more conservatively—from 0.42 International Monetary Fund Special Drawing Rights to .66 (x 1.57) over the decade to 10 June 2011. SDRs are a synthetic reserve currency, and reflect the values of a basket of 4 international currencies: US$, Euro, GBP and Yen. The $A is the world's fifth most traded currency as a proxy for commodity prices. This extreme currency movement, which may have some way to run, is having a massive impact on short-run regional prosperity and will, over time, trigger large-scale spatial adjustment.

5.0 Key Processes Shaping the Future of Australian Agriculture

Given today's uncertainty and volatility, it is extremely difficult, and probably unwise, to sketch complete scenarios of future Australian agricultures even in the short-term. Apart from estimating global supply and demand conditions for different commodities, we would have to infer (a) a large raft of fluid public policies, both international and domestic, and (b) second-guess the impact of numerous nascent technologies. The addition of spatial perspectives about the evolving strengths, weaknesses, opportunities and threats faced by different regions would vastly compound the difficulty. Instead I will sketch 11 key and strongly interconnected issues likely to shape agricultural geographies in coming decades. Together they point to a substantial research agenda.

5.1 Currency Movements and the Gregory Thesis

The appreciation in the A$ value on the back of the soaring value of mineral and energy resources could dramatically trim farm incomes. Global prices of farm commodities are generally set by such agencies as the Chicago Board of Trade / Mercantile Exchange in $US terms. Thus, the doubling of the value of the Australian dollar relative to its US counterpart over the last decade will *ceteris paribus* halve export incomes. In practice, this is mitigated by other countervailing events. According to the FAO, global food prices rose 2.3 times in the decade to May 2011, more than off-setting the $A's movement. Its index

commodities are meat, dairy, cereals, oils and fats, and sugar[2]. Adjusting for inflation, real prices rose a little less. In practice, Australian producers serving the domestic market (ca. 1/3rd of the total by value) would be substantially immune from these changes, but exporters would be at a competitive disadvantage in international markets relative to producers in countries with weaker currencies. On the bright side, the price of imported agricultural equipment would have shrunk substantially in recent years, provided dealers pass on the savings from appreciating currency. Such considerations differentially affect agricultural sectors. Those with a largely domestic market, like horticulture, would be much less affected than segments that are largely export focused like cotton (95% exported), wool, grains and meat products. These differences could, in the long term, reshape spatial patterns of commodity production. Gregory (1984) originally drew attention to these processes during an earlier, but short-lived, Australian mining boom in the late 1960s and 1970s. His analysis, which anticipates the structural damage to most non-mineral production as the result of a rising exchange rate, remains pertinent. Indeed, we noted above the incipient collapse in manufacturing employment by 2040 to less than 5% of the workforce. At its peak in 1970, manufacturing employment accounted for 30% of the workforce. Indeed, the exchange rate impact of the current boom could be much greater and more long-lasting than before, and it's already here.

5.2 Adjustment Imperatives Imposed by the Gregory Thesis

Sorensen (2009a, 2009b; 2011a) argues that the combination of large external pressures (like exchange rate movements and fluctuating global commodity prices), risky domestic environments exacerbated by frequently severe droughts and low-level internal support in a fundamentally market-oriented economy forces farmers to be highly flexible and adaptive. This takes several forms, including:

a) Lightning-fast adoption of research and development (analogous with Onnes' superconductivity as demonstrated by Sorensen, 2011a)
b) Rapid commodity switching, according to climatic or market conditions
c) Commodity diversification; expanding into new commodities
d) Outsourcing all manner of inputs: agronomy, soil science, water management and dam construction, GIS, expert systems, financial management, marketing, transport and logistics, machinery, fencing, etc.
e) Downplaying tradition and promoting risk-taking (behavioural responses akin to those discussed at length by Sorensen (2010).

These strategies, and others that are discussed below, will doubtless be reinforced by the extreme stress imposed by operating in a global world that is likely to become more uncertain, competitive, risky and clouded by the A$'s appreciation against the $US or SDRs. At this stage there is little evidence that the Australian government is about to protect agricultural trade artificially, for that goes against the stated views of both major political groupings for the last 30 years, so well-known adaptive strategies will remain in place, if not be accentuated.

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[2] See http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/ for summary details of the FAO Food Price Index and its time series movement.

5.3 Generating Scale Economies

Large is beautiful, and Australia's most profitable farm enterprises, and those most likely to access improvement capital, are big operations. Consider this: farm cash incomes (receipts less costs) for the top 25% of farm enterprises averaged a little less than A$200,000 in 2009-10, though that was the smallest amount in a decade. The data source for this information much of this section was the ABARES (2011) Farm surveys report (FSR), an annual publication containing a wealth of financial and other performance information for the past 3 years disaggregated by commodity class, geographical regions, and farm business size. The top 25% also generated 58% of broadacre production and 85% of farm business profits. The middle 50% and bottom 25% averaged about A$40K and minus A$10K respectively. Moreover, the top 25% of farm enterprises by cash income unsurprisingly accounted for 55% of capital improvements (excluding land purchase), while the bottom 25% accounted for just 10% (Sheng, Zhao and Nossal, 2011). The importance of scale economies to farm strategies is highlighted by rapidly rising land prices over the last decade. For example, real (inflation-adjusted) per-hectare land prices for broadacre farms rose from A$270 (1999-2000) to A$515 (2009-10) (ABARES, 2011, figures in 2009-10 $). Much of the rush to increase the size of holdings was debt financed. Real average farm debt rose from A$240,000 to A$540,000 over the same period, with about half of that going to land purchase. However, in any one year only between 4 and 6% of farms acquire land, and probably relatively few large operations are driving the process. In an added twist, the players in this game are also increasingly foreign corporations and this trend looks set to continue. While many nations are worried about food security, the notion has yet to gain much traction in Australia, probably reflecting our large food surplus.

5.4 Rising Global Competition

This is a huge wild card in proceedings, and goes much further than the potential outwash of the Gregory Thesis. Here are some straws in the wind:

a) Sharply rising agricultural productivity in EU accession nations, especially Poland and Hungary
b) Development of Russia's full agricultural potential, maybe aided by global warming in its northern regions
c) Erosion of peasant agriculture and its replacement by more efficient corporate models across industrialising Asia and even South America and parts of Africa
d) A large-scale reduction in EU agricultural support programs, maybe occasioned by member states having to repair disastrous public finances, which could lead to a reduction in low productivity small-scale farming through the amalgamation imperative already experienced in Australia
e) A new green revolution, driven by some combination of genetic improvement, application of machinery, greater use of fertilisers and other means of soil improvement, better storage and handling of food as it is moved from farm to market, and sound irrigation techniques. Numerous writers, including Alston et al. (2009), argue the current need for a comparable research and investment effort to the first green revolution of the 1960s
f) A rush to secure ground-water rights in Sub-Saharan Africa: at least three countries (China, India and Saudi Arabia) are known to have leased vast tracts of African land at knock-down prices to use un-exploited subterranean water to boost food output for export back to those countries. The Saudis have invested in Sudan, while China and

India are in Ethiopia, and all are motivated by their own potentially disastrous domestic over-exploitation of ground-water. One estimate puts 175 million Indians and 130 million Chinese at risk of hunger from over-use of groundwater[3]. This strategy makes citizens of poor countries like Sudan and Ethiopia more susceptible to drought (Ananthaswamy, 2011)

g) Diversion of food commodities away from ethanol production and back to human consumption
h) Greater use of such technologies as hydroponics.

5.5 New Business Models

The icon of Australian farming used to be the family farm; often small-holdings worked by a blue-collar family. This era is thankfully passing as the number of self-described farmers declines at about the long-term average of 1.5% per annum. Many larger-scale replacements may also be booked for extinction as they exert little competitive power compared with corporations. The Australian Agricultural Company, Heytesbury Holdings, and the Stanbroke Pastoral Company (the largest of the three) are well-known examples of major corporations whose scale enables them to operate in remote regions. For example, Heytesbury Cattle runs 150,000 head over 24,000 km^2 (9,375 $miles^2$) of cattle country mainly in top-end stations like Victoria River Downs. However, many of the large agricultural enterprises are private corporations and it is difficult to estimate their value (e.g. Stanbroke). The Australian Agricultural Company (AACo) is exchange-traded and figures are available. Its capitalization is A$440 million.

This helps explain something strange about Australia's maps of farm cash income ABARES (2011, p9). The most profitable operations are located on much the worst land. The reason for this massive negative correlation is simple. The logistics of operating profitably under the harshest of circumstances are so daunting that only large corporations (or family enterprises) have the financial and logistics capacity to remain in business. Janet Holmes à Court, the CEO of Heytesbury, is of sufficient stature to have been on the Reserve Bank Board, so we are talking here of the pinnacle of Australian business life. This is a metaphor for likely events in the agricultural heartlands under great pressure.

5.6 Research and Development

It seems likely that there will be substantial additional investment in Australian research and development. This is a respectable prop to an industry under great stress, especially in an era where great additional quantities of food and fibre have to be produced, pushing up both prices and returns on investment. And there is no shortage of research themes, especially in Australia's physical environment. For example, one enduring theme has been the genetic modification of crops and livestock to suit a dry and climatically capricious continent. In the past, for example, Droughtmaster cattle appeared when European cattle breeds (e.g. Shorthorn) were crossed with Bos Indicus (Zebu) cattle from the Indian Sub-continent to create an animal well suited to the heat and drought of the northern Rangelands (Stephens, 2006). More than a century earlier, the importation of Merino sheep from Spain and their subsequent breeding delivered an animal well-suited to dry conditions. Similar attention could be paid to developing crop varieties more tolerant of hot dry conditions

[3] Lester Brown, President of Earth Policy Institute (February 10, 2011). *New Scientist*

and poor soils often encrusted with salt. Two issues stand out particularly: the need for varieties requiring less water uptake; and varieties that have enhanced nitrogen fixing properties to deliver higher yields in poor soils. For example, Coghlan (2011) notes that the science behind modification of grains to perform the same trick as rhizomes in fixing nitrogen from the air could soon be a reality after many years of research effort. There would be an added bonus to enhanced production in avoidance or environmental pollution coming from synthetic fertilisers. In addition, Australia has a large number of native foods, already adapted to local conditions, which may find a niche in world markets. It will be a research-intensive task to compress processes that evolved with European plants over many centuries into a few generations. Australia is already a few steps down this path with the Rural Industries Research and Development Corporation program for new plant products[4].

5.7 Input 1: Energy

This is likely to be one of the great good-news stories of the 21st century. Corporate farming is highly energy intensive, especially in the use of liquid fuels, and its efficiency and effectiveness could be torpedoed by the interaction of fuel shortages and rising energy costs. Fortunately, the transition to renewable energy looks like it will be fast and relatively inexpensive. There is, in effect, no energy constraint at all, with estimates of available renewables at up to 1000x current global energy consumption. Moreover, constraints imposed by a lack of liquid fuels may well evaporate if we can coax cyanobacteria into literally endless production of bio-fuels (Jabr, 2011). Moreover, many parts of the world can participate in this bonanza, though Australia is likely to be particularly well-placed in the proceedings through its portfolio of stormy waters and coastlines, hot rock geology, and access to intense sunshine. And nuclear energy is also likely to be part of the base-load electricity system. Corporate farms especially are likely to be able to finance complete energy self-sufficiency in the near future.

5.8 Input 2: Sufficient Skilled Workers

Rural labour markets in many countries are often perceived as weak, with high unemployment among poorly skilled workers compared to their urban counterparts. In Australia's case this perception is misplaced. In fact, it is the other way around, with often tight regional labour market conditions exacerbated by shortages among the kinds of professionals providing specialist advisory services now greatly in need by corporate farms. The Heytesburys of this world are rather like General Motors or Toyota assembly plants, purchasing a vast range of inputs or, if sufficiently large, having specialist in-house advisors. The professional functions are almost limitless: agronomy and soil science; geneticists; GPS and IT; expert systems and artificial intelligence; marketing; financial and legal services; machinery and equipment supply and maintenance; construction; and transport and storage. Australia, at least, needs to ramp-up its education and training programs to prevent a workforce shortfall like that currently plaguing the mining sector.

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[4] See: http://www.rirdc.gov.au/programs/new-rural-industries/new-plant-products/new-plant-products_home.cfm

5.9 Input 3: Fertilisers

Fertiliser supply is looming as a major danger for agriculture as world supply of phosphates and other important soil additives begins to dry up. This explains why BHP, easily the world's largest mining company, attempted in 2009-10 to acquire the Potash Corporation of Saskatchewan, the world's largest fertilizer enterprise, for $40bn. It produces the three primary plant nutrients: potash, phosphate and nitrogen, but the move was banned by the provincial government aware of the impending shortage of such nutrients and their likely increasing value. BHP is still on the prowl. Of course, takeovers do not increase supplies and assuage the major threat. At least a high-valued currency will make it easier for Australian farmers to acquire fertilisers, assuming that global trade remains free.

5.10 Environmental Concerns 1: Climate Change and Water Scenarios

This is a work in progress, clouded by huge uncertainty. Although models suggest a slow drying of southern Australia and wetter tropical regions, the detail is largely missing on what locations will be most seriously damaged or enhanced and by how much. Even the timing of rain events could be crucial for the agricultural productivity of various locations. The capacity of the Murray-Darling basin, Australia's food bowl, to provide irrigation water has been studied in considerable depth and we now know that governments overallocated water entitlements in the 1960s and 1970s. However, the necessary extent of water claw-backs in different parts of the basin is unclear because overallocations were unevenly distributed and the appropriate form or extent of compensation is uncertain. They are still being vigorously debated. Even where water allocation is reduced the effects could be highly variable depending on farmers' capacity to invest in water-saving infrastructure or switch into higher value-added crops per mega-litre of water.

5.11 Environmental Concerns 2: Regulation and Conflict (e.g. diseases, competing land uses)

Finally, we come to an even greater mess. Farming, it seems, has an unparalleled capacity to generate conflict between different users of countryside, between individual commodity producers, between farming and mining interests, and between farmers and environmental interests. These conflicts are mediated by an evolving raft of laws, institutions, or organisations, themselves often shaped via the ballot box and hostage to the causes of the moment. Mercifully, Australia is an island and therefore much less hostage to pests and diseases than many countries. This has been strongly and effectively policed by AQUIS, the quarantine service, but how long this is possible in an increasingly mobile world is open to question.

6.0 Spatial Impact

How will all these variables impact on Australia's agricultural production and wider rural economies? Well, massively. I suspect that we are looking at a substantial reconfiguration of agricultural production over the next decade: how much of each commodity is produced where and how; market destinations; enterprise ownership, size of holdings and profitability; range, quality and sources of inputs; volume and structure of debt and gearing ratios; resilience of farm enterprises to external shocks; adaptability; risk acceptance and quality of entrepreneurship; corporate strategies and priorities; and quality of environmental protection. Since the great bulk of rural Australia owes its livelihood to agriculture and mining, it follows that the service system and the

towns it creates will also be substantially revised. Both sets of processes will create a swathe of winners and losers and both big agriculture and large diversified service centres will tend to be among the former.

Some qualifications to this general perspective should be expressed. Locations in the Sahel belt (or grassy rangelands) have limited alternative options to grazing, although cattle, sheep and goats or even camels (!) are in some cases substitutable. On the other hand, good soils and ample water found in parts of the ecumene greatly magnify substitution possibilities. Large rural enterprises fail suddenly from time to time where excessively geared and poorly managed, as happens frequently in Australia's forest industry when managed (pooled) investment schemes operate. Some larger rural service centres can also fall on hard times when their underlying rural economy is damaged by environmental disaster (e.g. floods and drought) or changing consumer lifestyle tastes and preferences. On the other hand, small boutique producers, like those populating the wine industry and organic production, and small lifestyle service centres can sometimes hit the jackpot by emphasising difference and quality or leading in fashion. In all these cases what matters is not blind adherence to tradition where it becomes the dead hand of history, but the quality of entrepreneurship and capacity for rapid adaptability to changing circumstances.

Moreover, producers of particular commodity types are often at different stages in the evolutionary cycle. In this paper, corporate farming was earlier described as a coming trend. However, corporate management was most prominent by the mid-2000s in pigs and poultry production (10.7% of the total), moderate (3.3%) in grains and cropping, and barely visible in beef, dairy and mixed farming. So corporatisation also has a spatial dimension, with the largest absolute number in the Northern (New England) region of New South Wales, which is home to numerous cotton producers, large grain properties and some large-scale cattle enterprises (several > 30,000 ha in size).

Indeed, if those circumstances are as turbulent as expected, adaptability will increasingly become the cornerstone of rural resilience. Here, Australian producers are well served because of the lack of state support and the increasing requirement that they make their way unaided in the world's market places. One example of this flexible production and rapid adjustment to changing circumstances was the sheep industry. In 1988, the wool to lamb (meat) price index was 230; twenty years later, by 2009 it was 48 (Reserve Bank, 2010). In effect, the price of sheep meats rose by a factor 4 against wool and the outcome was dramatic: the sheep flock dropped 60% and switched from wool to meat production. Over that period the wool clip dropped from 1000kt to 390kt and lamb exports rose from 300kt to >400 kt. Moreover, pastoral regions switched to beef production because of soaring Asian demand. In 1988, Asia took 32% of beef and veal exports; twenty years later the region took 61% of output, but gross output had also risen 64% in the meantime.

Conclusions

So, I am bullish about the future and can see a golden age for rural production looming in which income, wealth and quality of life steal a march on the nation's large cities. Alas, only some producers will remain in business, while the losers from change fall by the wayside. A market economy is a hard master, and Schumpeter was correct in seeing at its heart a gale of creative destruction choosing winners and losers. All one can confidently predict is that rural Australia generally, and agriculture as one of its core components, are in for a very rough ride. While lumpy change is normal in the best of times, both uncertainty and instability indices are likely to rise. And why, perhaps, would

anyone want to work on the land when they can join the mining sector? The current mining boom is turning the national economy upside down. Fastest wages growth is now among labourers (+22% over 2008-10); stationery plant operators (+21%); transport 'professionals' (including truck drivers +18%); and plumbers (+15%). And one pastry-chef in the Pilbara now earns more than the Chief Justice of Victoria.

The antidotes to such uncertainty and fluidity are: high quality entrepreneurial vision; good access to adequate risk capital; the rapid uptake of agricultural research and development in addition to the modification of new technologies; flexibility in production systems; and development of both appropriate and adaptable workforce skills – coupled with strategies to retain valuable workers. In short, rural Australia needs to replicate the culture of Silicon Valley described by Florida (2002) and many others, but under vastly different geographical circumstances. Rural Australia is home to a tiny 7 million people scattered over an area as large as the continental United States south of the 49th parallel. As I have argued in Sorensen (2011a), this can be done other than by replicating the top - down protective strategies of the European Union reported by Bryden *et al* (2011). The recipe relies instead on a combination of market forces, intensive research and development partly financed by government, global trade and investment, and information technology to force-feed an avalanche of change. This agenda appears to have little support among rural communities beyond Australia's borders, which is their problem not ours.

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