What's happening to agriculture?

The benefits of technological transitions

David Tribe

> I call the points where a rapidly developing technology takes off and starts to displace its predecessor 'technological transitions'. These are perilous times, but they are the times when great industries are founded. Rarely do leaders of the last technology play a significant role in the next; they've usually become encumbered with a bureaucratic superstructure focused on managing a mature market but incapable of acting on the small scale with the rapid pace that's needed to develop its successor—the new market that's inexorably displacing them.

John Walker, Founder of Autodesk Inc.

Drought, low commodity prices, dumping by overseas competitors, unfavourable terms of trade, barriers against entry into overseas markets, outbreaks of crop-destroying plant disease, to mention a few. There are plenty of problems for Australian primary producers to worry about, and it's easy to understand why some threats might be pushed to the background by more urgent distractions. Against this background, technological change can easily become just one more of these background issues. But this would be a serious strategic mistake, because massive global investment in biotechnology is triggering several major technological transitions in agriculture. Even though these are slow revolutions, they are still highly disruptive.

As with the telegram, the typewriter, the floppy disk, the land line telephone, and the snail-mail letter, all technologies have finite life spans and are vulnerable to displacement from the market by disruptive new techniques and innovations. If technological innovation is not embraced, it only moves faster somewhere else.

SUGAR

World markets for sugar and starch commodities are now virtually certain to see a fundamentally different—and much cheaper—form of sugar enter markets in 2006. This impending technological disruption consists of cheap sugar from polymer cellulose and it merits close analysis by Australian rural industries.

Cellulosic polymer materials (also called biomass) are the principal carbohydrate component of straw and wood, and are abundantly available—for example, as wheat straw, corn stover, sugar cane bagasse, wood chips, paper pulp—at low cost. A recently demonstrated commercial capability for cheap conversion of cellulosic materials into sugars essentially doubles the world supply of sugar from cereal crops and also enables woodchips and pasture grasses to be converted into more valuable sugar feed-stock streams. Thus, an economically disruptive technological transition is now occurring which, in the medium-term, is highly relevant to world sugar, starch and ethanol commodity markets, and one that can be used almost immediately to reduce ethanol biofuel costs.

For some 30 years or so now, it has been technically feasible but economically prohibitive to convert cellulose into sugar commodities. Thanks to astounding progress over the last three decades in molecular genetics and microbial biotechnology, this cost barrier has been broken.

The breakpoint in commercially feasible conversion of cellulosic materials into sugars was signalled by the April 2005 announcements made by a consortium which includes the Danish biotechnology company Novozymes, the US biotechnology company Genenecor, and the US National Renewable Energy Laboratories (NREL). These announcements heralded a 30-fold reduction in enzyme catalyst cost in a biomass-to-ethanol project. 'The project goal has been achieved: the cost of enzymes for biomass-based fuel ethanol production has been reduced to USD 0.10-0.18 per gallon in laboratory trials, a 30-fold reduction since 2001. Enzymes are no longer the main economic barrier in the commercialisation of biomass [cellulose to ethanol conversion] technology', said an April 2005 Danish stock exchange announcement.

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The Spanish energy company Abengoa has subsequently announced that a 70-tonne-a-day ethanol fuel demonstration plant will be commissioned late in 2006 at the BcyL Cereal ethanol factory at Babilafuente, Spain, which will use the technology to convert wheat straw into fuel ethanol. Steam explosion technology is an important straw pre-treatment stage in this process.

There is potential for further catalyst cost reductions in the process which could bring the cost down to the US$0.02 per gallon level or even lower. NREL has indicated that such progress is achievable by the continued application of well-tested biotechnology research strategies. Novozymes and Genencor are very well placed to exploit their long-acknowledged leadership in this area by extensive improvement of this technology. (Genenor is actually an extremely successful industrial offshoot of the first ever genetic engineering company, Genetech.)

Innovation in biomass conversion is being applied in Brazil to achieve further improvements to efficiency in the production of Brazilian ethanol biofuel by the Dedini Rapid Hydrolysis process. In 1975, the average yield of Brazilian ethanol was only 2,000 litres per hectare of cane crop; by 1998, technological innovation had pushed this to 5,500 litres per hectare. With the new biomass conversion technologies, the sector now has the potential to achieve yields of 10,000 litres per hectare or better. The improved methods can also be used to increase ethanol output from mashed corn, as can be done in the US biofuel industry.

Already, Brazilian fuel ethanol has become a substantial part of international trade, and currently competes commercially on US fuel markets, even with the penalty of a 51 per cent US excise tax. This dominant global trade position in ethanol liquid-fuel capitalises on 30 years of previous technological improvement, including earlier introduction of higher yielding cane varieties and numerous integrated changes to ethanol factories. The recent wave of ethanol fuel ventures in Australia cannot afford to ignore the reality of markets dominated by very cheap Brazilian ethanol and the prospects of even lower priced Brazilian and US ethanol in the near future.

Cereal straw and sugar cane bagasse are not the only cellulosic starting materials which can be converted to sugar using enzyme catalysts: wood and many other non-food crops can also be used, and forest industries in Canada and Scandinavia have particular interests in this area.

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The growth generated by market demand for this now price-competitive technology is likely to be augmented further in those countries that place a premium on its high potential for reduction of net atmospheric carbon dioxide emissions. All biomass-based fuel ethanol starts out, of course, as carbon dioxide sequestered from the atmosphere. Fuels from petroleum and natural gas do not have this environmentally beneficial first step built in, because their carbon has not seen the atmosphere for millions of years. In this way, biofuel is neutral with respect to atmospheric carbon dioxide levels, a crucial distinction between it and fossil fuels.

THE AUSTRALIAN COTTON INDUSTRY

Australia is a technological leader in the cotton industry, and Australian cotton productivity is three times the world average. Australian cotton has ridden the leading edge of a technological transition sweeping through the global cotton-growing industry to the advantage of cotton growers and their local communities. Current low world prices for cotton (and continued strong demand by China for cotton imports) have been augmented by a wave of technological change—including a genetic revolution—that has diffused through major cotton-producing countries such as the USA, Australia, China and, most recently, India.

Modern plant breeding is playing a decisive role in this economically disruptive but beneficial-to-the-consumer transition. The continuing global progress with this revolution, which started in Australia and the US in 1996, is illustrated by recent comments made by Zhang Rui, a member of a research team in the Chinese Academy of Agricultural Sciences. In September this year, he announced that China has approved commercialization of a new hybrid variety of insect-resistant Bt cotton—which contains a protein that kills bollworms—that should yield 26 per cent more cotton. The last two seasons have also witnessed truly dramatic improvements in the Indian cotton industry productivity. Widespread use of genetically modified cotton seeds has helped assure India of a bumper 2005 cotton harvest, with national output estimated at 25 million bales, up seven per cent from 2004.

Cotton's technological transition has significantly changed the supply side of the global cotton industry. Increased supply from widespread higher crop yields has added to recent stagnation in global cotton prices and enhanced prospects that low prices will continue in the near-term. Australia cotton growers have minimized the damage of low prices to their industry because they were innovation leaders and have been early in capturing benefits with well-managed and well-coordinated investment in cost-reducing and quality enhancing technologies over several decades. Unfortunately, cotton producers in counties that lag behind in technological innovation, such as in West Africa, are suffering severely from current low cotton prices, underlining the consequences of delayed innovation and the importance of reciprocal trade in cheap textiles to capture benefits.

OILSEED

Globally, the major transition occurring in the oilseed industry is the recent emergence of several 'health-enhancing' low-trans-fatty acid oilseed commodities—encouraged by new labelling regulations for trans-fatty acid content in the US and increased awareness of the health implications of trans-fatty acids in foods.

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Australia is having mixed success in riding this wave of innovation. One encouraging success is the Victorian-based seed company, Nutrihealth. Nutrihealth has developed novel canola oilseed varieties it calls Monola. These are new speciality oilseed varieties with fatty acid profiles decsribed in nutritional terms as 'High Oleic acid Low Linolenic'. While retaining the important nutritional attributes of canola oil, they have potential for a wider range of food applications, including oils with low trans-fatty acid content.

But export markets offer additional challenges beyond those provided by domestic markets for a speciality oil such as Monola in Australia. It is difficult to argue that Australia is well placed on these major export markets, particularly given the major technology transitions and heavy research investment taking place internationally, most notably in soybeans, the dominant part of the sector.

The huge soybean sector is undergoing substantial acreage growth in South America and is very attractive to commercial seed companies because of its large size. This combination of size, technology and research investment gives overseas soy growers tools to compete strongly in markets currently held by Australia's major oilseed crop, canola. For instance, several new soybean varieties will reach the market in the US in 2006 that provide health-beneficial fatty acid profiles that minimize the levels of trans-fatty acids in processed oils, and more are sure to come.

Technological innovation in most major crops in Australia has recently suffered a serious setback, by a wave of State Government legislation prohibiting any general farm cultivation of new crop varieties that are created using modern genetic manipulation (GM crops). This has prevented any further Australian commercial investment in modern crop genetics for the foreseeable future, other than in cotton, opium poppies and cut flowers. The Governments implementing the bans seem unconcerned that the Australian canola industry has conceded a 20 per cent cost advantage to Canadian growers for the next ten years or more, and seem to have no understanding of the time lags in the seed-breeding research pipeline. The cost to Australian agriculture communities of this legislation has been estimated by ABARE at $3 billion, but the long-term, flow-on economic damage from lost opportunities and diversion of commercial investment and intellectual capital to more attractive ventures in North and South America and China has not been fully assessed.

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WHERE TO FROM HERE

The technological changes in global agriculture are complex. Wisdom, bipartisanship and clarity of vision are sorely needed to navigate them. So far, there is only modest evidence of Australia's policy gatekeepers successfully tapping into these assets, except, to the country's great benefit, in the cotton industry.

One interesting area to start building a platform of sound policy might be the biofuel industry, since the apparently sustainable and carbon dioxide friendly nature of this technology seems to have softened the usual anti-technology stance of major environmentalist lobby groups. Ethanol biofuel doesn't make economic or environmental sense without the tools and discoveries of modern biotechnology. Without this, Australia would be better off importing its fuel ethanol from South America.

Setbacks to farm profitability and investment caused by GM crop bans show that technological leadership entails much more than just science and the costing of economic returns and agronomic benefits. They represent destruction of basic economic freedoms and threats to the medium-term financial viability of several rural industries. Resolution of this damage might come from a frank assessment of the misjudgements of industry, farming groups, and politicians that caused them, as well as an action plan to change stakeholder strategies.

If it is indeed true that they were driven by political calculations about urban votes rather than government attention to the interests of the rural sector, stronger activism by farming organizations, such as the National Farmers Federation and other networks such as the recently established Producers Forum (which is a loose national network of concerned growers), are a very welcome sign.

Australia exists today partly because of the pragmatic liberal attitudes to science and technology that held sway in Britain three centuries ago and the prosperity that flowed from the British enthusiasm for innovation. Nowadays, it often seems that enthusiasm for technology is confined to the internet and the latest generation of mobile phones. It might be wise to restore this traditional enthusiasm and extend it to the modern technological revolutions being embraced by our trade competitors.

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