



*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

# China's agriculture, smallholders and trade: driven by the livestock revolution?\*

Allan Rae<sup>†</sup>

China's sustained rapid economic growth and development has contributed to the surge in consumption and production of livestock in that country termed the livestock revolution. Consumption trends are first reviewed, and changes in food consumption patterns include a marked shift away from grains and towards meats and dairy products. A question is to what extent this rapid increase in demand for livestock products is reflected in China's agri-food trade statistics? While her agri-food imports have dramatically increased since China's accession to the WTO, livestock products have not made a noticeable contribution, although the import of certain animal feedstuffs has. This implies China's continuing self-sufficiency in most livestock products. The paper next considers developments in China's livestock farming sector and policies that have been contributing to these supply-side developments. The paper concludes with an examination of issues that may be important to the future development of China's, and the world's, livestock situation; this includes future demand developments, and the question of whether future demand growth in China might be met with local production, imports of final product, and/or imports of feedstuffs.

**Key words:** China, livestock, trade, domestic markets.

## 1. Introduction

The so-called livestock revolution (Delgado *et al.* 1999)<sup>1</sup> has occurred most obviously in China (Zhang 1999; Waldron *et al.* 2007). In recent times, both consumption and production of meat, milk and eggs have increased in China at rates well-above those for the developing world in general, and even faster if compared with developed countries. What are the opportunities this revolution provides for agriculture, trade and smallholders in China and elsewhere in the developing world? While one view is that the global revolutionary growth has tended to occur in the poultry and dairy sectors, where large-scale integrated operations may be the major beneficiaries, there is hope that the revolution will provide income gains and a pathway out of poverty for millions of smallholders in the developing world (Brown 2003). Others

---

\* This is an abbreviated version of the Presidential address to the 52nd Annual Conference. With the usual caveats, I am grateful for the helpful advice and comments of Scott Rozelle, Hengyun Ma, Funing Zhong, Scott Waldron, Weiming Tian, Anna Strutt and Francis Tuan.

<sup>†</sup> Allan Rae (email: a.n.rae@massey.ac.nz) is Professor and Director of the Centre for Applied Economics and Policy Studies, Massey University, Palmerston North, New Zealand.

<sup>1</sup> Delgado *et al.* describe this as the massive global increase in demand for food of animal origin as a result of growth in population, urbanisation and incomes in developing countries.

warn that the livestock revolution will not affect people equally – larger farmers in developing countries with access to credit and knowledge are likely to benefit, but smaller farmers may find it more difficult (Zhou 2003).

China's rapid income growth has seen the country follow similar trends to other developing countries with increasing consumption of high-value agri-food products<sup>2</sup> including those from livestock. Can such trends be expected to continue, and how would they impact on China's and international markets? Some in the economics profession have had a propensity to project China's imminent emergence as a major agri-food importer, to the point of 'starving the world', although such dire outcomes have not yet materialised.

The paper first describes how food consumption patterns in both urban and rural China have been changing, and then presents China's agri-food trade situation over the last couple of decades. A focus is on the rapid growth in imports over the past few years. To what extent was this growth in import demand driven by the increased consumption of animal products? Developments in China's animal production sector are then discussed, along with the influence of policy reforms and improved incentives to livestock producers, increased productivity, and structural change towards specialised production. The paper is concluded with discussion on China's possible future roles as an international trader in livestock products and feedstuffs.

## 2. Changing food consumption patterns in China

Since the late 1970s, both urban and rural incomes have grown at average rates of 7 per cent annually, but since 1995 urban incomes have grown at an annual rate of 8 per cent compared with 4.5 per cent for those of rural residents. The share of food in total urban household spending declined from 58 per cent in 1978 to 36 per cent in 2006. For rural households, the decline was from 68 to 43 per cent (Tian 2007). While nominal urban and rural food expenditures per capita have not shown much growth since the mid-to-late 1990s, the changing patterns of Chinese diets (Yang and MacAulay 2004) include the increase in the share of animal products (meats, fish and dairy products) in total food expenditures in both urban and rural households (Ma *et al.* 2004b<sup>3</sup>). Within urban households fish, poultry, beef and milk are taking rising shares of household spending on animal products, at the expense of pork (the traditional meat in Chinese diets), eggs and mutton. A similar situation exists in rural homes.

Urban and rural residents differ not only in their average disposable incomes, but also in the types of food market environments within which they make

---

<sup>2</sup> My definition of agri-food covers agricultural raw materials whether foods or not, plus food, raw or processed. Fish is excluded. HS commodities are 01, 02, 04-15, 1601, 1602, 17-23, 2401, 4001, 4101-4103, 5001, 5002, 5101 and 5201.

<sup>3</sup> This study attempted to adjust consumption data so as to include away-from-home consumption.

their consumption choices. It is important to differentiate between urban and rural residents, since despite rapid migration, rural residents still comprise close to 60 per cent of the total population. Urban residents increasingly purchase through supermarkets and department stores<sup>4</sup> and face a wide range of eating-out opportunities, while rural areas tend to be under-served by modern commercial marketing channels. This situation gives rise to substantial differences in food consumption levels and patterns between urban and rural residents. Between 1990 and 2006 in urban households, average in-home consumption per capita<sup>5</sup> of grains almost halved, while that of pork, beef, poultry, eggs, fish, milk and fruits all increased (NSB). The most rapid increases in urban per capita consumption between 1990 and 2006 have been for dairy products (296 per cent) and poultry (144 per cent). In rural households, these products also have shown the most rapid growth – 179 per cent for poultry and 392 per cent for dairy (from a very low base, and over the period 1995–2006). In rural households, where local culture and traditional habits shape diets and significant food consumption is from own-production, the decline in the average per capita grain consumption was substantially less than for urban households, although consumption of all meats, fish and milk showed relatively large increases (Tian 2007). Absolute consumption levels per capita for grains are much higher in rural households than in urban, but for meats, fish and milk average per capita consumption is substantially higher in urban households. There has also been increasing demand for diversity, convenience, safety, healthy and for semiprocessed and ready-to-eat food products especially among urban consumers.

Aggregate food consumption trends in China also reflect the rapid migration of consumers from the countryside to urban locations. Total population growth from 1990 to 2005 averaged 0.9 per cent per year, while that of the urban population was 3.5 per cent per year. It is now well-known that such urbanisation of the population is a powerful explanator of changes in purchasing patterns. Rae (1998) showed that for many Asian countries, urbanisation had a positive and significant effect on the demand for animal products after controlling for price and income effects. For China, he estimated expenditure and urbanisation elasticities of 0.68 and 0.90, respectively, and also found that the consumption response to a marginal increase in expenditure was positively related to the level of urbanisation. Continuing

---

<sup>4</sup> But from a low base – wet markets are still the dominant source of purchases of urban residents. In fact much of the meat, fruits and vegetables sold in supermarkets have been purchased from wet markets as often are foods sold in urban restaurants (personal communication, Scott Waldron).

<sup>5</sup> These statistics do not accurately incorporate away-from-home consumption. Survey results are 'discounted' according to the number of meals eaten away-from-home by family members (Funing Zhong, pers. commun.). The quantities of food eaten away-from-home and their impacts on the quantities eaten at home are likely to be under-reported and/or underestimated. Furthermore, there is no consumption survey covering the over 100 million immigrants who might still be considered members of rural households.

migration is therefore expected to contribute to further increases in consumption of animal products as newly-urbanised consumers lift their consumption levels, and change their expenditure patterns towards those of their urban neighbours.

The data from the National Statistics Bureau (NSB) does not accurately incorporate food consumed away-from-home. Therefore (especially) the urban NSB consumption data are likely to be biased downwards, especially for live-stock products. Among urban consumers, almost 9 per cent of food expenditures were on food away-from-home in 1993, but this share rose to nearly 21 per cent by 2005 (Tian 2007). While urban per capita food expenditure has been relatively stagnant since 2000 the share of food consumed at home has fallen as away-from-home eating opportunities have rapidly developed in China's urban areas. Income growth plays a central role in determining the level of away-from-home demand, but it has been shown by Ma *et al.* (2006) that it also affects the structure of those expenditures towards the consumption of meats and fish. They estimate an expenditure-elasticity for away-from-home consumption of 1.74, which rises to 2.54 for household members in the top income quartile, and an expenditure elasticity of 0.98 for spending on meat away-from-home. These demonstrate how growth in away-from-home consumption has been driven by income growth in urban areas that increases the participation of this population in eating out.

### 3. China's agri-food trade

China has shown a positive trade balance in agri-food products for most years since 1949. This situation changed in 2003, and from that year on the trade balance has been negative. While the value of agri-food exports has recently increased along the longer-term trend, imports increased sharply from 2002, just after China's accession to the World Trade Organisation (WTO). By 2006 agri-food imports totalled US\$31 billion compared with \$11.1 billion in 2002 – a threefold increase.<sup>6</sup>

To what extent was China's recent agri-food import surge driven by increasing consumer demands from the urbanised and wealthier middle classes for livestock products and other items with relatively high income elasticities? The unexpected answer is perhaps that 60 per cent of the increase in imports between 2002 and 2006 was accounted for by just three products: soybeans, cotton and natural rubber. Products demanded by industry (cotton, natural rubber, raw hides and skins and wool) contributed 41 per cent of the growth in agri-food imports, reflecting the growth in the textiles, clothing and shoes, automobiles and construction industries in China. Imports of all animal products, food or otherwise, comprised just 7.9 per cent of the overall growth

---

<sup>6</sup> Trade data are sourced from United Nations Commodity Trade Statistics Database (COMTRADE), with all values reported in US dollars.

in agri-food imports, of which hides and skins, and wool, contributed 6 per cent. Dairy products made up 1.7 per cent of that increase, and meats even less. This suggests that China has been largely able to supply increased demands for animal products from local supplies, albeit along with a rapid growth in soybean and other feedstuffs imports to supply its livestock feed sector. China has been a net importer of soybeans since 1996, and by 2006 was the world's leading importer, at 28.3 million tonnes (Gale 2007). On the export side total livestock products made up 13.5 per cent of the overall 2002–06 increase in agri-food exports, to which meats contributed 11 per cent. Horticultural products made up over half of the export growth.

While livestock products have not made a noticeable impact on China's recent agri-food trade development, what has been happening in terms of China's trade in these products? Net exports of live animals, meats and dairy products combined fell from US\$1.7 to \$1.1 billion between 1996 and 2006. Over this period China remained a net exporter of meats with a trade balance of \$1.3 billion in both of those years. By far the major meat category now exported is preserved and processed product, with net exports of \$1.26 billion in 2006, compared with \$0.33 billion in 1996. Through high-temperature treatment, this category of product is able to overcome importer bans due to the presence of animal diseases, such as foot-and-mouth, in China. Between the mid-1990s and the early 2000s net exports of poultry, pigmeat and beef all declined, but since then beef and pig meat (until late 2007) net exports have risen rapidly. China was a net importer of sheep/goat meat from 1998 until 2004, but since 2003 imports declined and China had an increasing export surplus of this meat from 2005. Net exports of ruminant meats (beef and sheep/goat meat) rose from \$9 million in 2000 to \$73 million in 2006 – beef imports fell in response to BSE outbreaks in North America; over the same period pigmeat net exports rose from \$10 million to \$380 million. The quantities traded are generally very small compared with total production: the net export quantities of pig meat and beef were 0.4 and 0.25 per cent of domestic production, respectively, in 2005. China's net exports of poultry meat have been declining since 1996, and turned into a net deficit since 2002, although the net import volume was just 1.5 per cent of domestic production in 2005. China has a trade deficit in dairy products, with net imports rising steadily from \$24 million in 1996 to \$464 million a decade later.

The global agri-food trading environment has changed abruptly over the past year, due largely to droughts in major producing countries and rapidly increasing demands for cereals and oilseed crops for bio-energy production. It is rather early to say whether this is a major structural change or a temporary phenomenon, but it has had a major impact on China's food markets, as elsewhere. For example in China feedstuff prices are at historically high levels and are rising ahead of prices of many livestock products, squeezing margins of livestock producers. This problem has been exacerbated by disease outbreaks among China's pig inventory – as a result the wholesale pork price

rose 86 per cent over the year from July 2006. Imports of pork have soared, reaching 21 000 tonnes in the first half of 2007 compared with 24 000 tonnes for the whole of 2006. Pork exports have sharply declined from the year earlier although the country remained a net exporter of this commodity in 2007 despite becoming a net importer over the last third of that year (Honye You, pers. commun). Maize exports also raced ahead – up 85 per cent over the first 11 months of 2007 compared with the same period of the previous year. In response the Chinese government placed export taxes and quotas on maize and other crops in an effort to curb rising exports of these commodities and to reign in domestic food price inflation.

China's trade policies were reformed in preparation for eventual accession to the WTO (OECD 2005). Since 1992, China's most-favoured-nation (MFN) agricultural tariffs have been reduced from a simple average of 45 per cent to about 33 per cent in 1997 and 15 per cent in 2005, and further reductions continue for some commodities as per China's WTO schedule. The dispersion of China's agricultural tariffs is also relatively low, with around 67 per cent of tariff lines having tariffs of < 20 per cent. Since substantial agricultural liberalisation took place in China between 1995 and 2001 in preparation for accession, the subsequent accession did not lead to a significant fall in protection on most agricultural commodities after that date (Anderson *et al.* 2007).

The surge in China's agri-food imports therefore has more likely been driven by the wider aspects of China's industrial growth, accession-related reforms and the abolition of the Multifibre Agreement (MFA) textile and clothing quotas rather than agricultural reforms *per se*. Major factors include the substantial liberalisation of foreign investment into pillar manufacturing and services industries and the gradual withdrawal of the state from its dominant position in such industries that contributed significant productivity and income gains (Mai *et al.* 2003), increased activity in China's textile and clothing sectors that contributed to increased demand for cotton imports, and the surge in auto manufacturing (8.9 million vehicles produced in 2007 vs. two million before 2000) that increased the demand for rubber. China's livestock revolution, however, did contribute through the huge growth in protein feedstuffs.

## 4. China's agricultural and livestock policies

### 4.1 The post-cultural revolution policy reforms

These reforms were initiated in the late 1970s under the leadership of Deng Xiaoping. First and fundamentally, private incentives were introduced from the early 1980s through the gradual replacement of the commune system with the household responsibility system, within which farmers were given the freedom to allocate resources based on market signals and to sell their surplus products (over and above government quotas and targets) in free

markets thus increasing their income through production and market diversification (Tuan and Ke 1999).

By 1984 the General Food Company (GFC) structure and its meat companies, which was set up in the 1950s to manage the supply and marketing of livestock and other non-staple foods using sales targets and set prices, completely monopolised the pork, sheep/goat meat, beef and poultry production and distribution sectors. But from the mid-1980s government began to decentralise agricultural production and distribution by gradually liberalising fruit and vegetable markets, followed by fisheries products, livestock products and oilseeds. Controls over the marketing of most commodities were eased considerably and urban and rural free markets were rapidly introduced and expanded (Lewis and Andrews 1989). Most non-grain products including livestock had been liberalised by the early 1990s (Gao *et al.* 1996). The pig purchase quota was replaced by free market trading, eggs were traded freely and all provinces abolished the beef quota system (Waldron *et al.* 2003a). The Government's Vegetable Basket Programme was introduced in 1988 to encourage infrastructural improvements in rural areas and development of a network of wholesale markets, and has contributed to the rapid development of the vegetable, livestock and fisheries sectors.

It would be a mistake to attribute the recent growth in the livestock sector in China to market forces alone, however. Government directives, policy pronouncements and other non-market incentives have played an important role in the growth of some livestock industries – recent promotion of the dairy industry is a case in point. But it should also be noted that once the industry in question fades from government attention, it tends to contract, and sometimes and especially in some areas it may contract sharply. The Chinese beef industry is a good example but so too is the Chinese fine wool industry (Waldron *et al.* 2007). The State has also maintained control or influence over some aspects of the livestock industry. Exports of live farm animals and meats have been subject to quota (to Hong Kong and Macao) or export license, and State agencies control the production and distribution of breeding materials including importation of breeding stock. The State, through the activities of local officials, guide the activities of householders in a number of ways including the provision of support services, and the construction of animal production facilities (Waldron *et al.* 2003a).

Since the late 1990s, government policies have recognised the imperative of increasing farm and rural incomes, narrowing the rural-urban income gap, increasing the competitiveness of China's agriculture and reducing the tax burden on farmers. A series of 'No. 1' documents since 2004 have set out the government's recent agricultural and rural policy objectives. Increasing farm incomes and enhancing foodgrain security have been addressed through grain marketing reforms introduced from 2004 that include minimum prices (rice and wheat), direct payments based on grain area sown, and subsidies for higher quality seeds and some machinery. Agricultural taxes in China had been in place for over 2000 years and had, amongst other things, contributed



to peasant revolts and the downfall of dynasties. These taxes were equivalent to 8 per cent of the value of farm output in 2003, and were phased out over the period 2004–06. The fourth document of 2007 has a focus on the promotion of modern agriculture. The ‘multifunctions’ of agriculture are to be developed, including agro-tourism, bio-energy, sustainability and rural environmental enhancement. Attention is also given to product safety and quality standards, including GIs, certification, labelling and traceability systems. Increases in direct state subsidies to agriculture were announced.

#### **4.2 Are China’s livestock and feeds producers taxed or protected?**

Recent research has attempted to quantify the extent to which China’s agricultural and trade policies have distorted production incentives over the post-1978 reform period (Huang *et al.* 2004, 2007; OECD 2007). During the early reform years, compulsory purchase of grains and livestock products at low prices resulted in returns to farmers well-below world levels. In this period there was heavy implicit taxation on pig and poultry production, also due to China’s policy emphasis on grains and to Chinese<sup>7</sup> and foreign restrictions on trade in these products. The gap between domestic and world prices of these livestock products has narrowed considerably since the late-1990s and producers have been able to respond to these improved incentives to meet the growing domestic demand. Although China has, since 1994, had no policies that would hold pork and poultry prices below world levels, barriers imposed by importing countries ensure that nominal assistance rates (Huang *et al.* 2007) remain negative. Positive protection of milk remains, but at levels considerable less than those of a decade ago or earlier. Turning to feedstuffs, nominal rates of assistance for maize farmers have been positive since the mid-1990s. While soybean producers have received positive protection each year since the early-1990s, this protection has fallen sharply in recent years as trade protection was liberalised and China became integrated into the global soybean market. So for at least the past decade, poultry and pig producers faced the double disincentive of negative protection of outputs and positive protection of their major feed inputs.<sup>8</sup>

The OECD (2007) has recently estimated support to Chinese agriculture, taking account of other sources of assistance to farmers in addition to policies impacting directly on output prices. Their producer support estimates (PSEs) increased from 3 per cent on average over the 1995–97 period to 10 per cent by 2003, but have since declined to 8 per cent in 2005. Changes in China’s PSE are driven mainly by the evolution of support for grains: between 2000 and 2003 the crop PSE rose steadily while that for livestock declined some-

---

<sup>7</sup> Voluntary quotas were in place in the 1990s, primarily to avoid supply shocks in the Hong Kong and Macao markets (Tian 2007).

<sup>8</sup> Rae (1992) found similar situations in many South-east Asian livestock sectors in the late-1980s.

what (OECD 2005, figure 2.14). An implication is that further agricultural trade liberalisation by China would not be expected to have much further impact on China's production and trade patterns, apart from a few exceptions such as dairy products. In today's relatively liberalised agricultural economy, Chinese producers can better respond to movements in international prices, as demonstrated by the rapid structural change from grains to livestock and horticultural production wherein lies the comparative advantage.

### 5. Recent developments in China's livestock production sector

Domestic livestock production has, by and large, been able to cater to the domestic demand expansion. China's agricultural output has expanded rapidly since the economic reforms of the late 1970s, reflecting both productivity growth and mobilisation of inputs. Among livestock products over the period 1996–2006, output of beef and mutton has increased by 111 and 160 per cent, respectively, poultry meat production has increased by 81 per cent, pork output by 65 per cent, egg output by 68 per cent and milk production by a massive 650 per cent (Tian 2007).<sup>9</sup> Real gross agricultural output value (GAOV) has grown by 6.2 per cent per year since 1990, but the output of the livestock sector grew even more rapidly, at 8.9 per cent annually. Thus livestock's share of GAOV increased from almost 26 per cent in 1990 to 32 per cent by 2006 (NSB 2007). The livestock demand growth revolution was responsible for an even greater share of the agricultural output growth when crop feedstuffs are considered – while the increased livestock share occurred at the expense of the cropping sector, more land has been planted in maize (mainly substitution for wheat) at the same time as the total area sown in cereals has declined.

While the growth in animal numbers explains much of this output growth, productivity gains in China's livestock sector have also been striking. Rae *et al.* (2006) used provincial enterprise-level livestock data for China, and estimated total factor productivity (TFP) annual growth rates of 3 per cent to 5 per cent for hogs and eggs, and 4 per cent for beef over the 1990s. This study also decomposed TFP growth which revealed that growth in technical change occurred in all livestock sectors at rates between 3 and 6 per cent. However, the rates of catch-up had been very slow or even negative, due in part to the deterioration of the extension system (Nyberg and Rozelle 1999). This suggests scope for future output growth if inefficient farmers can move

---

<sup>9</sup> Concerns have been raised over the historical accuracy of China's livestock production statistics, and an increasing discrepancy over time between supply and consumption data and lack of consistency between output data and those on feed availability (Ma *et al.* 2004a). These problems are likely to have been more severe before 1996, at which time China's National Bureau of Statistics revised livestock data based on the first national agricultural census. It is believed that their livestock data are to be revised again in 2008, based on the second national census of agriculture.

closer to the technical frontier. TFP growth for milk was much slower than for the other enterprises at 0.5–1 per cent, although growth in technical change was much faster at over 6 per cent. This slow TFP growth was not unexpected given that the milk sector in China has recently been undergoing very rapid growth with many new entrants, producer experimentation and inevitable mistakes, and some slow adopters of new technologies. Nevertheless, a subsequent study (Ma *et al.* 2007) estimated a milk TFP growth rate of just over 2 per cent per year for specialist dairy farms in suburban locations – of interest since the location of milk production is moving nearer to major markets and as much as 50 per cent of China's total milk production could now be occurring in such locations.

Backyard, part-time animal-raising is still the dominant form of livestock production in China. Livestock smallholders made up around 99 per cent of all livestock operations, and produced 73 per cent of hogs, 82 per cent of cattle, over 60 per cent of poultry, 73 per cent of sheep and 65 per cent of dairy cattle (MOA 2003). For most of these livestock smallholders a significant proportion of household income comes from other sources. But recent structural changes have seen a decline in the proportion of rural households that are raising livestock (Zhang 2006), and the emergence of specialist household producers as well as commercial, large-scale enterprises especially in suburban regions of large cities. In the RCRE<sup>10</sup> survey the proportion of sample households that raised livestock fell from 76 per cent in 1995 to 54 per cent in 2005, with the average share of total household income derived from livestock rising from 11 per cent in 1995 to 14 per cent ten years later (Rae and Zhang 2007). The specialist household systems<sup>11</sup> have a larger scale than the backyard systems and tend to be more market-orientated (Tian 2007). But the household sector, whether specialised or not, remains dominant in China's livestock production and Chen and Rozelle (2003) suggest that financial difficulties experienced by some of the commercial operations may have been driven by competition from specialist household producers.

Since the late-1980s the Chinese government has taken measures to encourage development of intensive feedlots aiming at ensuring stable supply of quality products, and their numbers have been growing since the early-1990s. They tend to be located in either coastal regions with access to markets and ports, or in provinces with abundant feed supplies. Compared with backyard systems, feedlots are more capable of controlling quality and achieving scale economies. However their economic performance can be very susceptible to changes in input and output prices, as recently experienced with higher feed costs, and to problems regarding management and husbandry, disease control,

---

<sup>10</sup> The Research Centre for Rural Economy, Ministry of Agriculture, Beijing. This survey is conducted annually and includes over 20 000 rural households in 31 provinces.

<sup>11</sup> The Ministry of Agriculture officially defines households as specialised in an activity if it earns at least 60 per cent of its income from that activity. In practice, specialisation is defined in terms of livestock heads or turnover.

inadequate technical and training services and risk-sharing and insurance (Wang 2007).

Structural change is also rapid in the milk sector (Ma *et al.* 2007). Urban demand growth has encouraged the development of milk production as well as the rapid expansion of processing facilities in China's suburban areas (Zhou *et al.* 2002). The government has implemented a wide range of measures to promote the development of suburban dairy farms, including the provision of concessional loans for investment, feed subsidies, the supply of improved breeds and the provision of technical assistance to producers (Wu *et al.* 2006). The injection of foreign capital and the introduction of advanced technologies has also helped to promote suburban milk production (MSTC 2004). As has been the case in other livestock industries, 'concentration centres' in suburban areas are a recent phenomena in the dairy sector (Yi 2005). Small and scattered dairy farmers in the countryside are driving their cows into the concentration centres where they can rent space for their cows, and/or buy cows to start their business, and enjoy relatively modern production and marketing services such as access to concentrate feed, new owner training programs, animal disease control, milking facilities, milk collection and transportation.

A structural change in hog production over the past two decades has been the growth of backyard hog production in the poorer inland regions and its contraction in the richer inland areas and coastal provinces. Chen and Rozelle (2003) put this down to the emergence of grain and feed markets in inland regions that facilitated hog production, and of improved labour markets in coastal areas that increased the opportunity cost of labour remaining in farm production. Using the RCRE data, Chen and Rozelle find support for the hypothesis of poorer households increasing livestock production in early stages of their development, but of decreasing livestock activity once household incomes reach a certain level (FAO 1999), which they term the 'rise and fall of backyard hog production' in China. In the beef sector, Longworth *et al.* (2001) found that cow/calf and breeding operations tend to be carried out only by poor semisubsistence households. Such small scale production may not be profitable if the opportunity costs of labour are considered, so when labour markets develop that households can access, they may exit the cattle industry.

Between 1995 and 2005, many households in the RCRE sample exited livestock production. Of those rural households that were surveyed in both of these years, 21 per cent did not raise any livestock in 1995. By 2005, this percentage had more than doubled to 48 per cent. During the 1990s China's livestock markets experienced over-supply problems and price corrections, which would have influenced many households to move out of livestock production. These market problems occurred in the egg industry in 1996–97, the pork industry in 1999–2000, and the beef industry experienced a sharp market correction in 1996–97 following its rapid expansion in the first half of the 1990s. Such market developments encourage industry rationalisation, and in the beef industry hundreds of thousands of households left the industry

in the late 1990s (Waldron *et al.* 2003b). Specialised households responded more to the market corrections than did the more diversified households due in part to their 'hard' budget constraints (relative to more diversified households) that result from their greater dependence on commercial markets for inputs such as labour, capital and feedstuffs and greater exposure to risk (Longworth *et al.* 2001).

The growth in the livestock sector in China is being accompanied by the rapid development of modern supply chains. It has been found in other countries (Reardon and Swinnen 2004) that in such cases it is richer and larger farmers who benefit, rather than poorer, smaller farmers. Is this likely to be the case on China? Some evidence suggests that *large* commercial hog farms are emerging to service urban consumers (Fabiosa *et al.* 2005) and that an increasing volume of beef (from a very small base) is being sold through modern supply chains (Brown *et al.* 2002), but that *small* producers are increasing their participation in milk production (Wu *et al.* 2007). Based on surveys of livestock producers in Beijing and Hebei province, Bi (2007) concludes that there has been little penetration of modern supply chains by these producers, with the one exception of poultry production. While pig production in the survey was split evenly between poorer and richer households, the vast majority of poultry production occurred in the richer households. Given the role of supply chains in marketing poultry, it is concluded that the entry of these operators gives rise to increased scale of production and the exclusion of poorer households. In contrast, the poor were seen to benefit and increase market share (but not scale) when livestock are marketed primarily through traditional supply chains as is the case for pork.

## 6. Looking ahead

### 6.1 Will China's demand for livestock products continue to grow?

Much of China's rapid growth has been driven by investment and the export surplus, and hence less by increases in consumption (Lardy 2007). Since 2000, household consumption as a share of GDP has been steadily falling while the GDP share of investment and (especially since 2004) net exports of goods and services have been increasing.<sup>12</sup> Consequently, between 1995 and 2006, real GDP per capita increased at the rate of 7.9 per cent per year, while that of per capita household consumption grew at the slower annual rate of 5.7 per cent. This has occurred despite the government's stated objective of strengthening domestic consumption as a major source of economic growth (Lardy 2007). There has also been a widening disparity between urban and

---

<sup>12</sup> Lardy provides an interesting comparison with India: in 2004, China's GDP per capita was two-and-a-half times that of India, but its per capita consumption was only two-thirds higher than India's.

rural incomes, and also between those in the coastal areas and elsewhere.<sup>13</sup> Looking ahead, how might growth in consumption's share of GDP, and a narrowing of the rural-urban income gap, impact on food consumption in China and on its trade with the rest of the world? Should consumption become more important as a driver of China's future growth, then a slow-down in GDP growth, as sometimes projected, need not lead to a slow-down in the growth of household consumption. Food demand projections that are based on projected growth in GDP might then underestimate future demand growth.

Possible scope for further increases in consumption of livestock products as incomes continue to grow is indicated by comparing the progression of rural consumption relative to that by urban consumers. Real disposable incomes in China's rural households were in 2005 at about the same level as in urban households in 1990 (Rozelle and Huang 2007). For milk and poultry meat the levels of per capita consumption by 2005 in rural households were also rather similar to those of their urban counterparts 15 years earlier. In both rural and urban regions, consumption of these products has been increasing linearly with real incomes, and consumption per person may well continue to grow, and not just in rural households. However, consumption of pork by urban consumers has levelled off, while that in rural households reached by 2005 the level of urban consumers in 2000. Scope for further increases in pork consumption by either urban or rural consumers is therefore perhaps limited. In the case of red meats, urban consumption appears to be levelling off, but that of rural households remains well-below that of urban consumers. While Tian (2007) concludes that China's future food demand growth will be largely determined by the rate of growth in rural incomes, urban income growth may remain an important driver for some livestock products and will also influence future growth in food consumption away-from-home. Future policy developments that affect migration, rural industrialisation, rural education and training, investments in new townships and cities in rural areas and the modernisation of food retailing in such regions can all be expected to play important roles in influencing the future growth of livestock product consumption in rural areas.<sup>14</sup> These will also help determine whether rural food consumption patterns will converge on those in urban areas as rural incomes approach those of the urban population.

---

<sup>13</sup> While the ratio of urban to rural incomes was 2.6 : 1 in 1978, it had risen to 3.3 : 1 in 2006. The Gini (per cent) coefficient has risen from 29 in 1978 to 37 in 2000 (Kanbur and Zhang 2005) and reached 47 in 2004 (WDI).

<sup>14</sup> For example access to many social services including education and health care has favoured urban residents, property rights differ between rural and urban residents and the population registration system (*hukou*) creates disincentives to the migration of rural-born residents (although recent relaxations have occurred in some metropolitan areas and villages (Cai 2007; Lardy 2007)).

## 6.2 Feeding China's Livestock

Rapidly growing domestic demand has driven the explosion of livestock production in China, which in turn has driven the rapid growth in demand for protein feedstuffs that was an important contributor to China becoming a net agri-food importer in recent years. Domestic production of feed crops, however, has also risen rapidly – and achieved against a backdrop of tight land constraints and a decline in the total area of sown cropland. The area sown in soybeans increased by 36 per cent between 1991 and 2006, while total output rose by 69 per cent (MOA). Under the 'soybean rehabilitation program' initiated in 1999 the government provided financial subsidies to farmers to adopt improved soybean varieties to raise yields and oil content, in response to the growth in imports. Maize is a different trade story. The maize area grew from 21.6 million hectares in 1991 to 27.0 m ha in 2006 – an increase of 25 per cent, and total output increased over the same period by 47 per cent. Despite the demand-side developments, China remained a net exporter of maize in most years since the mid-1980s. This is despite widespread concern over China's potential to switch to become a major net importer of maize and other grains.

While China's exports of maize do fluctuate considerably from year to year, China has so far been able to meet its demands for livestock maize feed from domestic sources, assisted in part by increased use of soybean meals in animal feeds. It is not clear for how long this will continue; but some factors suggest a slowing in the rate of growth of feed demand. Livestock feed efficiency has been increasing in China, which has resulted in savings of grain, and at the same time meat demand growth has switched from pork to poultry with its lower grain requirement per kg (the feed conversion ratio) of meat produced. Another factor influencing growth of demand for feedgrains is the slowing in the rate of production growth for both pork and poultry in recent years. Between 1996 and 2001 the annual production growth rates were 5.1 and 7.3 per cent, respectively, for pork and poultry, but these had both fallen to 4.5 and 4.6 per cent, respectively, for the 2001–06 period. While the expansion of ethanol production in China was largely fed from maize stocks, the government has since 2006 prohibited further use of grain for this purpose. On the supply side, recent government measures to encourage grain production have had some success, and potential still exists for further increases in maize production perhaps at the cost of soybeans and some minor crops. More recently the government has imposed export taxes and quotas on exports of maize and some other crops as part of an effort to reign in galloping food price inflation. Recent increases in maize and ocean freight prices have resulted in domestic prices for maize being below the landed cost of imports (Tian Weiming, pers. commun. 2007), and if this situation continues large-scale imports of maize do not seem to be on the horizon.

The development of bio-fuels could also impinge on China's (and others) demands for traditional livestock feedstuffs. Should grain and oilseed prices

continue to strengthen, and as increased supplies of by-products suitable for livestock diets emerge from the bio-fuels industry, changes in feed formulation practices may occur, involving a shift away from maize and soybean towards locally available feedstuffs and bio-fuel by-products. With the ban on grains as a bio-fuel feedstock, China has targeted sweet sorghum as one of several non-grain crops for bio-ethanol production. Simpson *et al.* (2007) suggest that the sweet sorghum bio-ethanol program will contribute significantly to China's total animal feedstuffs production. This is through two co-products: crushed stover (suitable for ruminants) which can be treated to increase its energy and protein content, and stillage from the grain distillation process which can be dried and to which microproducts can be added (and which can be fed to all animals and fish). Simpson *et al.* (2007) project that the sweet sorghum bio-ethanol program could allow China to reduce its imports of protein feed crops such as soybeans by about 21 per cent by 2030.

### 6.3 Meeting growing demands: imports of feed or final product?

Some countries, such as those in North-east Asia, have met increased demands for livestock products from their domestic animal stocks and from increasing imports of feedgrains until domestic supply constraints were reached, after which imports of livestock products grew. Others, such as China, have met their livestock products demand largely from domestic animal and grain resources. The question arises, especially in countries increasingly facing land, water, environmental or other constraints to livestock production, at what point might imports of feed grain be replaced by imports of meat products? It is not at all clear whether, and if so when, China will emerge as a persistent importer of grains for livestock feeding, or whether further into the future China will eventually import more grains embodied in livestock products. Hertel *et al.* (2007) project an increase in China's trade balance in non-ruminant meats, but declining trade balances for ruminant meats and for land-intensive crops and agriculture overall, between 1997 and 2025.

For the coming decade at least, China seems likely to continue producing livestock products at relatively low cost, given the labour-intensive nature of the production systems and the low opportunity cost of rural labour. The same can be said of the slaughtering and processing components of China's produced meats, resulting in labour shares of these activities in the final product being much lower than in developed countries. As a consequence further expansion of local production looks capable of supplying the continuing demand growth with the likely exception of dairy products (Ma *et al.* 2004b), albeit in the face of continuing risks of rising feed costs, animal diseases and environmental concerns and regulations (Tian Weiming, pers. commun.).

As China's consumers of animal products become more sophisticated, market demand will become increasingly segmented as some consumers express demand for higher quality products. Given China's ongoing problems



in reliably producing 'high-quality' livestock products, much of this demand could be met from imports. Thus trade, as well as markets, could become increasingly segmented as specific types of product are imported to meet specific market niches. For example China is a net exporter of generic beef, but imports premium beef for the restaurant and hotel markets and also imports very low-value beef for processing. For China's trade in poultry meats, the unit value of exports has always exceeded that of imports since at least 1996, for example by 50 per cent – 70 per cent between 2004 and 2006. This would imply that China exports relatively high-value cuts of poultry meat and imports low-value parts. Indeed, between 1999 and 2001, China was a net poultry meat exporter in value terms but a net importer in quantity terms.

## 7. Summary and conclusions

The question posed in the title of this paper was whether the livestock revolution had been a driver of China's agriculture, smallholders and agri-food trade. My conclusion is that this phenomenon has indeed revolutionised the agricultural sector and the livestock industry in China, but that with the exception of protein feedstuffs, it has as yet had very little impact on China's international trade. China has successfully increased livestock production more or less in line with her consumption increases, and the process has provided diversification and specialisation opportunities to millions of small-holder producers. But these developments have not been without periods of instability and declining prices, resulting in many producers exiting the industry. Specialist household and commercial operations are becoming more prevalent, encouraged in part, especially in the poultry sector and the richer coastal regions, by the growth of modern processing and retailing and the continuing exit of the traditional backyard producers, but face considerable financial and production risks.

The livestock revolution is expected to continue in China, although it may take different forms to those exhibited in the past as government and industry respond to existing and emerging problems and issues. Consumption of livestock products will no doubt continue to grow over the medium-term but probably at a slower rate than in the past. As higher-income consumers increasingly demand high-quality and safe livestock products, the industry will be required to respond through a variety of ways including continuing international cooperation in investment and technology development, and the improvement of backward linkages and integration involving the modern retail segment. A big unknown is, to what extent the domestic industry can continue to supply this demand growth, and especially as sustainability becomes a more important issue in China. Environmental problems are already occurring, with some large-scale livestock operations having been relocated away from suburban locations, such as dairy farms shifting out from the Beijing area and medium/large-scale hog farms having been forbidden in Shanghai.

Also, over-grazing of grasslands is already a problem in the cattle and sheep sectors. Increasing pressures on cropland raise the question of where the industry will obtain its future feedstuff and forage supplies, and the extent to which these will be sourced internationally. Negating these pressures somewhat are the prospects of new feedstuffs from emerging bio-fuels industries, and the likely slow-down in feedstuffs demand growth as the industry continues to improve efficiency of feed use. Should future high-grain prices seriously disrupt white meat markets, will lean ruminant meats, fed on China's supplies of crop and bio-fuel residues, increase their market share at the expense of white meats? If recent growth in beef and sheepmeat exports is to continue into the future, further efforts will be required to address food safety, disease status, inspection systems and other concerns of importers, which in turn will require greater investments in processing and distribution systems and inspection services. If successful, China might become a significant competitor for the traditional exporters of these meats?

Wages are rising rapidly in China, across both regions and industries, not only in absolute terms but relative to other economies. While the country, for some time, has experienced a shortage of skilled labour, will it one day face shortages, and rising wages, of unskilled labour as well? These labour market developments might impact on China's future livestock industries in at least two ways. As wages continue to increase it is possible that livestock farmers could be even more strongly encouraged to seek industrial employment, or that their children will increasingly choose off-farm employment over farm work. This could result in increased pressure on China's domestic supplies of livestock products. And given the labour-intensive nature of non-ruminant production and meat processing in China, the industry could see its price advantage eroded which may offer increased opportunities for foreign suppliers in China's markets.

## References

- Anderson, K., Martin, W. and Valenzuela (2007). Long run implications of WTO accession for Agriculture in China. Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Bi, X. (2007). Who is benefiting from China's livestock boom? Presented at WERA-101 Annual Meeting, Shanghai Jiaotong University, 12–13 July.
- Brown, A.G. (ed.) (2003). The Livestock Revolution: a pathway from poverty? Record of a conference conducted by the ATSE Crawford Fund, Parliament House, Canberra, Australia, 13 August.
- Brown, C.G., Longworth, J.W. and Waldron, S. (2002). Food safety and development of the beef industry in China, *Food Policy* 27, 269–284.
- Cai, F. (2007). How can globalisation benefit unskilled workers? Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Chen, J. and Rozelle, S. (2003). Market emergence and the rise and fall of backyard hog production in China. American Agricultural Economics Association annual conference, Montreal, 27–30 July.
- Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and Courbois, C. (1999). *Livestock to*

- 2020: *The Next Food Revolution*. Food, Agricultural and the Environment Discussion Paper 28, International Food Policy Research Institute, Washington, DC.
- Fabiosa, J.F., Hu, D. and Fang, C. (2005). A case study of China's commercial pork value chain. MATRIC Research Paper 05-MRP 11. Iowa State University, August.
- FAO (1999). Sustainable animal production from small farm systems in South-East Asia, FAO Animal Production and Health Paper 106.
- Gale, F. (2007). A tale of two commodities: China's trade in corn and soybeans. Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Gao, X.M., Wailes, E.J. and Cramer, G.L. (1996). Partial rationing and Chinese urban household food demand analysis, *Journal of Comparative Economics* 22, 43–62.
- Hertel, T.W., Ludena, C.E., Golub, A. and Rae, A.N. (2007). Food and agricultural trade and productivity growth in Asia: Baseline projections to 2025. Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Huang, J., Liu, Y., Martin, W. and Rozelle, S. (2007). *An Uncommon Agricultural Policy: Trade Liberalisation in China's Agriculture*. Working Paper, China Centre for Agricultural Policy, Beijing.
- Huang, J., Rozelle, S. and Chang, M. (2004). The nature of distortions to agricultural incentives in China and implications of WTO accession, in Bhattasali, D., Li, S. and Martin, W.J. (eds), *China and the WTO: Accession, Policy Reform and Poverty Reduction Strategies*. The World Bank and Oxford University Press, Washington DC.
- Kanbur, R. and Zhang, X. (2005). Fifty years of regional inequality in China: a journey through central planning, reform and openness, *Review of Development Economics* 9, 87–106.
- Lardy, N.R. (2007). China: Toward a consumption-driven growth path. Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Lewis, P. and Andrews, N. (1989). Household demand in China, *Applied Economics* 21, 793–807.
- Longworth, J.W., Brown, C.G. and Waldron, S.A. (2001). *Beef in China: Agribusiness Opportunities and Challenges*. University of Queensland Press, St. Lucia.
- Ma, H., Huang, J. and Rozelle, S. (2004a). Reassessing China's livestock statistics: analyzing the discrepancies and creating new data series, *Economic Development and Cultural Change* 52, 117–131.
- Ma, H., Rae, A.N., Huang, J. and Rozelle, S. (2004b). Chinese animal products consumption in the 1990s, *Australian Journal of Agricultural and Resource Economics* 48, 569–590.
- Ma, H., Huang, J., Fuller, F. and Rozelle, S. (2006). Getting rich and eating out: consumption of food away from home in urban China, *Canadian Journal of Agricultural Economics* 54, 101–119.
- Ma, H., Rae, A.N., Huang, J. and Rozelle, S. (2007). Enhancing productivity on suburban dairy farms in China, *Agricultural Economics* 37, 29–42.
- Mai, Y., Horridge, M. and Perkins, F. (2003). Estimating the effects of China's accession to the World Trade Organisation. Presented to 6th Annual Conference on Global Economic Analysis, 12–14 June, the Netherlands.
- MOA (Ministry of Agriculture of China). (2003). *Statistical Yearbook of Animal Husbandry of China*. China's Agricultural Press, Beijing.
- MSTC (Ministry of Science and Technology of China). (2004). The successful construction of modern demonstration dairy farms in the Northern large urban areas. [in Chinese]. <http://www.gongguan.most.gov.cn/info/showinfo.asp?id=2604>.
- NSB (National Statistics Bureau) (2007). *China Statistical Yearbook*. China Statistical Press, Beijing.
- Nyberg, A. and Rozelle, S. (1999). *Accelerating Development in Rural China*. World Bank Monograph Series, Rural Development Division, World Bank. Washington DC.

- OECD (2005). *OECD Review of Agricultural Policies: China*. OECD, Paris.
- OECD (2007). *Agricultural Policies in Non-OECD Countries. Monitoring and Evaluation*. OECD, Paris.
- Rae, A.N. (1992). Interaction between livestock and feeds policies: evidence from Southeast Asia, *Agricultural Economics* 7, 25–37.
- Rae, A.N. (1998). The effects of expenditure growth and urbanisation on food consumption in East Asia: a note on animal products, *Agricultural Economics* 18, 291–299.
- Rae, A.N. and Zhang, X. (2007). Smallholders, livestock and household income in rural China. Presented to WERA-101 Annual Meeting, 12–13 July, Shanghai.
- Rae, A.N., Ma, H., Huang, J. and Rozelle, S. (2006). Livestock in China: commodity-specific total factor productivity decomposition using new panel data. *American Journal of Agricultural Economics* 88, 680–695.
- Reardon, T. and Swinnen, J.F.M. (2004). Agrifood sector liberalization and the rise of supermarkets in former State-controlled economies: a comparative review, *Development Policy Review* 22, 515–523.
- Rozelle, S. and Huang, J. (2007). China's rural economy and the path towards a modern industrial state. Presented to IATRC Conference on China's Agricultural Trade: Issues and Prospects, Beijing, 8–9 July.
- Simpson, J.R., Wang, M.-J., Xiao, M.-S. and Cai, Z.S. (2007). China looks to sorghum for ethanol. Feedstuffs 79: Issue 36 (Part 1) and Issue 37 (Part 2), 3 and 10 September (online).
- Tian, W. (2007). Agricultural development in China. Presented to First International Seminar of the ALARN Network, Congresso Brasileiro de Agribusiness and Institute for International Trade Negotiations, Sao Paulo, Brazil, 28–29 August.
- Tuan, F.C. and Ke, B. (1999). A review of China's agricultural policy: past and present developments. In *Agriculture in China and OECD Countries: Past Policies and Future Challenges*, Proceedings of the Workshop on Agricultural Policies in China: Review, Outlook and Challenges, OECD, Aris, November.
- Waldron, S.A., Brown, C.G. and Longworth, J.W. (2003a). *Rural Development in China: Insights from the Beef Industry*. Ashgate, Aldershot, UK.
- Waldron, S.A., Brown, C.G. and Longworth, J.W. (2003b). Transforming lives with livestock-based agribusiness, in Brown, A.G. (ed.), *The Livestock Revolution: A Pathway from Poverty?* Record of a conference conducted by the ATSE Crawford Fund, Parliament House, Canberra, Australia, 13 August, pp. 27–39.
- Waldron, S.A., Brown, C.G., Longworth, J.W. and Zhang, C.G. (2007). *China's Livestock Revolution: Agribusiness and Policy Developments in the Sheep Meat Industry*. CAB International, Wallingford.
- Wang, O. (2007). *The Standardized Construction Models and Safeguard Mechanisms of Concentration Breeding Districts*. Unpublished paper, Research Center for Rural Economy, Ministry of Agriculture, Beijing.
- Wu, Y., Huang, J. and Rozelle, S. (2006). *Dairy Production and Marketing in China: A View from the Farm*. Working Paper, Centre for Chinese Agricultural Policy, Chinese Academy of Sciences, Beijing.
- Wu, Y., Huang, J., Rozelle, S. and Yang, Z. (2007). *The Rise of Dairy Processing Firms and Farmers Participation in Dairy Production in China*. Working Paper, Centre for Chinese Agricultural Policy, Chinese Academy of Sciences, Beijing.
- Yang, J. and MacAulay, G. (2004). The dairy industry in China: An analysis of supply, demand and policy issues. Presented to 48th Annual Conference of the Australian Agricultural and Resource Economics Society, Melbourne, February.
- Yi, M. (2005). *Planning Five Major Raw Milk Production Areas and Setting Milk Source Pattern*. China Breed Net. August 2005 [in Chinese]. [http://www.agri.gov.cn/fxycpd/xcpl/t20050812\\_436905.htm](http://www.agri.gov.cn/fxycpd/xcpl/t20050812_436905.htm).
- Zhang, C. (1999). *The Livestock Revolution in China*. In Proceedings of the Workshop on the

- Implications of the Asian Crisis for the Livestock Industry, FAO Regional Office for Asia and the Pacific, Bangkok, July.
- Zhang, X. (2006). The study of development trend for livestock smallholder in China, *Agricultural Outlook* 2006, 12–15.
- Zhou, Z. (2003). Feed versus food: the future challenge and balance for farming, in Brown, A.G. (ed.), *The Livestock Revolution: A Pathway from Poverty?* Record of a conference conducted by the ATSE Crawford Fund, Parliament House, Canberra, Australia, 13 August.
- Zhou, Z., Tian, W. and Zhou, J. (2002). The emerging dairy economy in China: production, consumption, trade prospects. *Australasian Agribusiness Review* 10: paper 8.