Modelling the implications for New Zealand trade and producer returns from different scenarios relating to the demand and supply of organic products

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Abstract

This paper describes historical, current and potential market opportunities for organic produce in New Zealand and overseas. New Zealand is unique as a developing country relying on agricultural production and trade for most of its foreign exchange earnings. The challenge for the NZ agricultural sector is to access high value markets, as consumer demand changes, away from price, to a greater focus on food safety and concern over the environment. We assess potential scenarios of development in the sector, using the Lincoln Trade and Environment Model (LTEM), a partial equilibrium trade model that differentiates between organic and conventional production methods.

Keywords: Trade Modelling, New Zealand, Organic Markets

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1. Introduction

New Zealand is unusual amongst the developed nations in that a main source of overseas income is through the export of agricultural commodities. This has contributed to declining relative growth rates for New Zealand, as agricultural commodities have fallen in value compared to other sectors. Returns to agriculture are diminishing (relatively) because agricultural commodities have a low income elasticity of demand. Thus the New Zealand agricultural sector thus needs to find ways of increasing its income.

The NZ agricultural sector has responded in various ways to falling real incomes. These include reducing the cost of production through economies of scale and increasing efficiency through different management and production techniques. Historically, many of these ‘initiatives’ are cost focused; the objective has been to produce the commodity at a lower cost per unit and thus achieving the ‘low-cost competitive advantage’. In addition the agricultural sector has diversified into alternative crops and animal products, such as kiwifruit and deer.

Another strategy pursued has been to segment markets to obtain price premiums. An example of this is the successful apple industry in New Zealand, as development of new varieties with improved attributes is continually taking place in an effort to maintain or gain market share and higher prices. It is also observed in the wine industry, where varieties such as ‘pinot noir’ and ‘chardonnay’ command superior prices to ‘muller thurgau’.

However, another type of attribute where agricultural products can distinguish themselves and attracting price premiums is the way in which the product is produced. Increasingly, consumers in developed markets are willing-to-pay for attributes that are perceived to improve because of the product’s method of production. These include the adoption of Integrated Pest Management (IPM) in apples and kiwifruit production, adoption of food quality schemes such as EURPGAP, but also food that is organically certified. Organic produce is distinguished from conventionally produced goods by the system of production utilised. It is this system that a growing number of consumers are demanding and are prepared to pay more for.

This study examines the potential risks and benefits of expanding organic agriculture in NZ (and other countries) using the LTEM (the Lincoln Trade and Environment Model) under various scenarios relating to the level of production and consumption, premiums and production costs. These scenarios are based upon a review of the international organic industry and trends in its development.

2. Market for organic goods

The demand for organic food and beverages is primarily attributed to food safety and health considerations (Elliott et al., 2003). An increase in personal health awareness has occurred, perhaps more urgently in nations that have experienced food scares (such as BSE in the UK), and this has brought attention to the methods used in intensive conventional agriculture, and a lack of confidence in mainstream food production. Others may prefer organic food as it has not been treated with pesticide, hormone or antibiotic treatments. Further to personal health, concern for the health of the environment is increasing around the world, especially in developed nations. Organic production methods are favoured over current conventional practices, as being more environmentally benign. Also ethical reasons have an influence on consumers demand for organic produce.

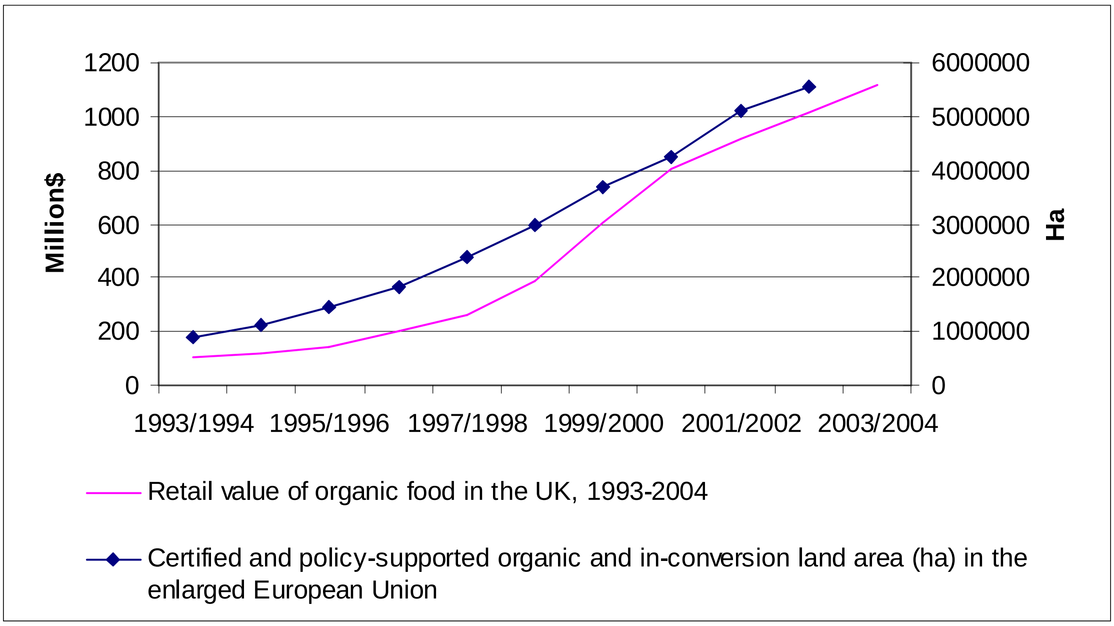
Many countries are experiencing growth in demand for organics. Market maturity has occurred in few countries on a limited range of commodities – so overall continued growth is expected, varying by degree across nations. Price premiums may decrease over time as the organic industry sector increases in size, yet potentially remaining at a significant level in a mature market. Production costs for organics may decrease over time given increasing economies of scale as the industry grows, but also due to improvement in production technology as research and service industry support develops alongside the expanding production.

All these factors contribute to the uncertainty and risks of the organic industry, and it is important for the sector to review potential risks and benefits of developments in the organic markets.

2.1 Organic production and consumption worldwide

Consistent time series data for the organic sector, for prices, production and consumption, is difficult to obtain and therefore in assessing the extent and likely growth in the sector a number of different sources have to be used. However, most sources of data do show that organic food markets have experienced substantial growth over the last ten years (20-30 percent per year). For example, as illustrated in Figure 1, the retail value has doubled in the UK from 1999-2004. Figure 1 also illustrates the growth in production with the organic land area in the EU-25 tripling from 1996-2002 (EISFOM, 2004; Soil Association, 2004; USDA Foreign Agricultural Service, 2004).

Table one shows estimates of the organic retail sales by key countries and their projected growth rates. This shows that in 2003 the retail value of the European market was estimated at US$10-11 billion and the US market at US$11-13 billion. In 2002 these two markets accounted for 97% of the world organic market. (Willer & Yussefi, 2004; Yussefi & Willer, 2003).



Source: (EISFOM, 2004; Soil Association, 2004)

Figure 1 Time trend of organic sales in the UK and EU production area

Despite the growth in the market for organics it still has a relatively small share of total retail sales, as illustrated in table 1, and these shares were according to Smith & Marsden (2003) almost stable between 1997 and 2000. Thus in the EU the relative shares are as follows; Germany (US$2800 million in sales, 1.7 per cent retail market share); United Kingdom (US$1550 million, 1.5 per cent retail market share); Italy (US$1250 million, 1.0 per cent retail market share); and France (US$1200 million, 1.0 per cent retail market share). The highest organic retail market shares within Europe are found in Switzerland, closely followed by Denmark and Austria. Germany, UK and Sweden follow thereafter. Japan and the US, dominates the markets in the Pacific and Northern America, with organics accounting for 2.0 respectively 0.5 per cent of the retail market share.

Table 1 Estimates of organic retail value, retail share and projected annual market growths 2003

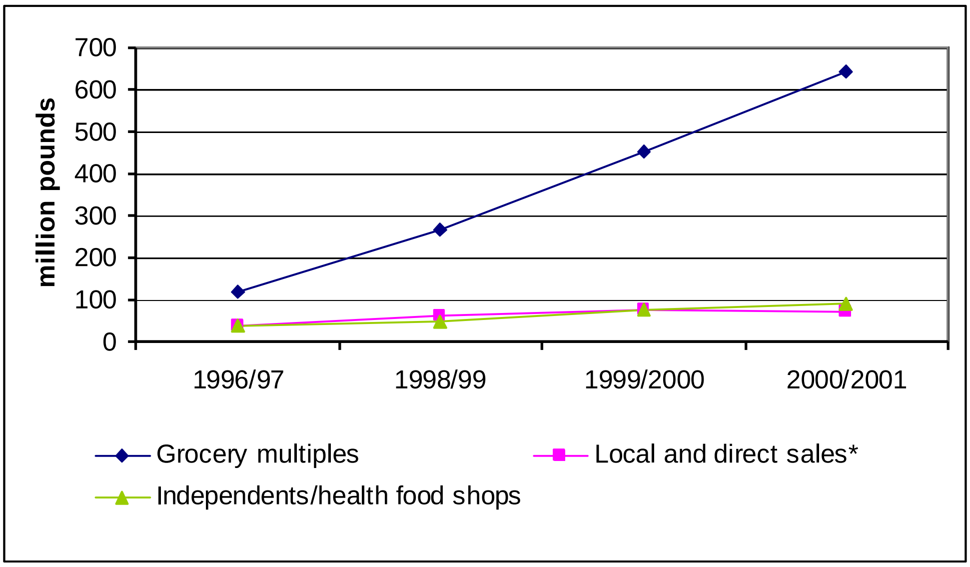
Market	Retail value (million €)	Retail share (% organic of total sales)	Annual market growth 2003-2005 (%)
Austria	325-375	2.0-2.5	5-10
Belgium	200-250	1.0-1.5	5-10
Denmark	325-375	2.2-2.7	0-5
France	1200-1300	1.0-1.5	5-10
Germany	2800-3100	1.7-2.2	5-10
Italy	1250-1400	1.0-1.5	5-15
Netherlands	425-475	1.0-1.5	5-10
Ireland	40-50	<0.5	10-20
Sweden	350-400	1.5-2.0	10-15
Switzerland	725-775	3.2-3.7	5-15
United Kingdom	1550-1750	1.5-2.0	10-15
Other Europe	750-850	-	-
Japan	350-450	<0.5	n.a.
China*	6	n.a.	n.a.
Taiwan*	9.7	n.a.	200
Australia*	123-130	0.2	400
United States	11000-13000	2.0-2.5	15-20
Canada	850-1000	1.5-2.0	10-20
Mexico*	12	n.a.	n.a.

Source: Willer & Yussefi (2004)
**1998 estimates from Lohr (2001).*

Price premiums on organic products vary a lot between and between different countries; Lohr (2001) found that price premiums for key markets were between 10 and 100 per cent above conventional products. In 2003, price premium were estimated to range between 10-400 per cent in China and between 50-75 per cent in Australia (Willer & Yussefi, 2004). Premiums in Europe vary considerably between countries as well as products, from 31 to 133 per cent (Hamm, Gronefeld, & Halpin, 2002) (15 to 77 per cent (La Via & Nucifora, 2002)). The La Via & Nucifora (2002) study of retail chains in Europe found the average premium across all types of outlets for organics was 51 per cent whereas the difference in premium across product categories within individual stores were only 14 per cent. The study does suggest that in the longer run a premium of between 20-30 percent in the large retail stores is most likely.

In more mature markets such as Denmark, Sweden and Switzerland, a more stable price premium between 10 and 30 per cent for dairy and meat products seems to be most common (Millock & Hansen, 2002; Teagasc, 2004).

The structure of organic food retailing seems to go through three stages over time from niche to maturing market with availability of organic products mainly sold in supermarkets (retail-chain-stores). Initially organic sectors are small with produce typically sold directly from producer to consumer. The market then develops, with an increase in amount sold through specialist stores. Final stages tend to have high processing and marketing costs. As the market goes through these three stages the organic market share grows (Christensen & Saunders, 2003).



Source: Organic Trade Services (2005)

Figure 2 U.K. Retail Sales of Organic Food by Distribution Channel

Thus organic products are mainly distributed through supermarkets (retail-chain stores), specialty stores and/or producer direct sales, as illustrated in table 2. Retail-chain distribution is a strong factor for the continuing growth of organic market share beyond what is possible through direct sales our through speciality stores. Due to a large customer base, supermarkets can generate turnover more quickly, thus reduce costs and maintain product appearance and quality. Furthermore, supermarket availability makes organic produce more accessible for the consumers.

Table 2 Percentage shares of organic retail market by distribution channel

Market	*Supermarkets*[1]	*Specialty stores*[2]	*Producer direct*[3]
Austria	77	13	10
Denmark	70	15	15
France	45	45	10
Italy	25-33	33	33-42
Germany	25	45	20
Netherlands	20	75	5
Sweden	90	5	5
Switzerland	60	30	10
United Kingdom	65	17.5	17.5
Japan[4]	High-end-stores	Widely available	Widely available
United States	31	62	7

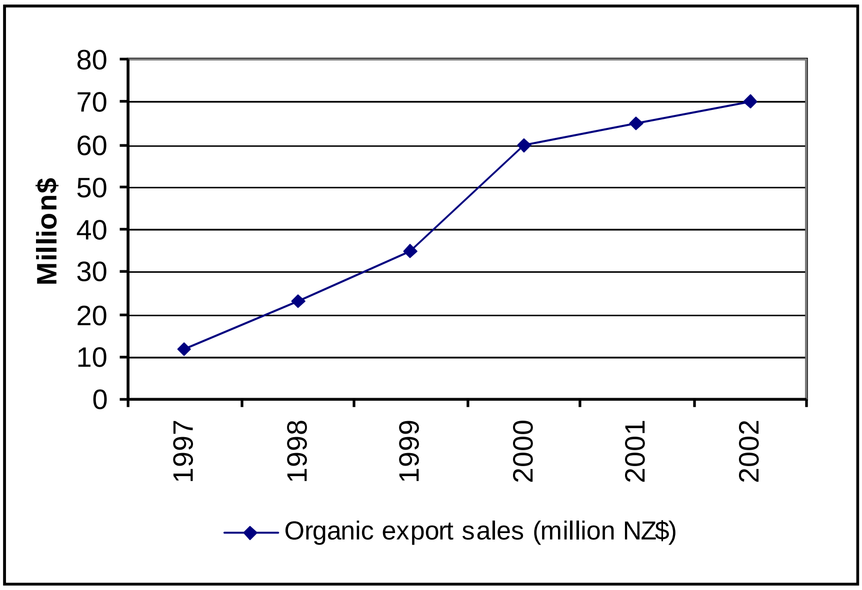
[1]Includes supermarkets and hypermarkets that offer conventionally grown foods
[2]Includes organic supermarkets, natural products and health food stores, cooperatives and other
[3]Includes on-farm sales, farmer markets, box schemes, CSAs, teikei and other
[4]Share data not available for Japan, but qualitative information suggests the relative availability of product in each country
Source: Lohr, 2001

Thus, as illustrated in table 2, in Europe the majority of organic produce is distributed through supermarkets (retail-chain stores) which may help to explain the relatively large share of organic produce in these markets. Moreover it is argued that as the US has moved away from a specialty store dominated distribution system this has contributed to the highest growth rates in organic sales of any country of 12 per cent in 2002 (Willer & Yussefi, 2004). This growth has also been fuelled by the establishment of a common organic standard. The continuing strong growth of organics market share in Switzerland has been contributed to the high involvement of the large retail chains (Willer & Yussefi, 2004). Similarly, the slow down of growth in organic sales in Denmark is sometimes attributed to the weak interest of the leading retail chains (Agra Europe, 2004; Willer & Yussefi, 2004). An exception to this dominance of retail outlets is the Japanese market where organic produce is mainly distributed directly from the producer or through specialty stores (Lohr, 2001).

2.2 Organic sector in New Zealand

Organic farming in NZ started as an idealistic movement in 1950-60s, consisting of a loose coalition of people with many different interests. However, in 1983 the coalition institutionalised itself by setting up New Zealand Biological Producers Council (BIOGRO), which from then on administrated production standards under the BIOGRO certification system (Saunders, Manhire, Campbell, & Fairweather, 1997).

Successful aggressive targeting of organic products to niche exports markets in the 1990s attracted attention to NZ organic food products. Exports of organic products has grown rapidly in the past, but slowed down considerably from 2000 to 2002. This is mostly because a strong growth in the domestic market and the slow adoption rate among sheep & beef and dairy (BioGro, 2004). More than 80 per cent of New Zealand's organic export is for the US, European and Japanese markets (OPENZ, 2002).



Source: BioGro (2004)

Figure 3 Exports of Organic products from NZ

Organic horticulture (vegetable and kiwifruit production) is relatively well established within NZ. In 2001 to 2004 approximately 3.5-3.8 percent of the yearly NZ of kiwifruit crop (number of trays) was organic (Zespri Ltd., 2004). Organic livestock and arable farms, however are a relatively low proportion of their sectors (Ministry of Agriculture and Forestry, 2002). Less than 1% according to Willer & Yussefi (2004). Thus, organic raw milk production is insignificant compared to total NZ milk production of 14,016 million litres (Fonterra Co-operative Group, 2004). In NZ in 2002 there were around 4,500 cows on organic farms, each producing 6,000 litres of organic milk, that is 27 million litres in total (not all of this is sold as organic milk though) (Mason, 2002). However, Fonterra has recently shown commitment to expand organic milk production offering a 20 percent producer premium for organic raw milk. The retail price premium within NZ for organic dairy products is considerable – especially for organic liquid milk, with a mark-up in 2001 of 51 percent on organic liquid milk in retail stores.

2.3 Cost of organic production

A 2002 MAF (Ministry of Agriculture and Forestry, 2002) study on costs and risks of conversion to organic production systems in New Zealand shows that for organic farms, milk production tends to be around 7 percent lower, gross farm revenue around 5 percent smaller, but also cash farm expenditure nearly 9 percent lower. This corresponds to an 10% price premium to generate the same cash surplus as a conventional farm. In the EU, milk produced per ha on organic farms is 70% to 80% of that on similar conventional farms, and the direct costs are lower (40%) (Connolly, 2002). Shadbolt et.al. (2004) refer to a 22-37% higher production cost for organic milk in the EU, a 13-23% cost increase in California, and an 11% increase in Argentina.

For the sheep and beef sector the MAF study of New Zealand production estimated a decrease in farm working expense by 8% and in revenues by 25% (no premium for organic). A premium of 23% is required to achieve the same EFS as conventional farms (Ministry of Agriculture and Forestry, 2002). The figures are similar for EU; overall direct costs of production decline by 10% under organic production and the output decrease by 15% (Connolly, 2002).

Clearly there are considerable uncertainties facing the agricultural sector in relation to the development of the organic sector. These include the ability to predict premiums and growth rates in the various markets. In addition the impact of additional production costs is largely unknown and thus affect the decisions whether to convert to organic production. Therefore, the next section of the paper, using the trade model (LTEM), assesses some of the potential impacts on NZ agricultural returns relating to various scenarios of price premiums and production costs.

3. Modelling changes in markets and trade

The empirical model used in this analysis was the LTEM a multi-country, multi-commodity model, focusing on the agricultural sector in a partial equilibrium framework.[1] The framework is used to analyse the impact of various shifts in demand or supply on the country and commodity based price, net trade levels and producer returns, with the commodities in the LTEM differentiated to organic and conventional. The model specification is given in brief in appendix 2 and in more detail in Cagatay & Saunders (2003).

Although commodities are differentiated as organic or conventionally produced, each grouping of differentiated commodity is considered homogenous across countries of origin and destination and to physical characteristics of the product. Therefore commodities are perfect substitutes in consumption in international markets. Importers and exporters are assumed to be indifferent about their trade partners. Based on this the model is built as a non-spatial type which emphasises the net trade of commodities in each region. However, the supply and demand shares of countries in trade can be traced.

The model simulates results using various assumptions in proportions of organic and conventional production, as well as assumed impacts or shocks to markets of various scenarios relating to the preference for organic production.

3.1 Empirical analysis

By running various scenarios in the LTEM associated with conventional and organic products, the model was used to estimate the impact on trade, prices, output, and thus producer returns for key agricultural commodities. The LTEM output is an estimation of the impact on producer returns from different assumptions relating to market developments for conventional and organic commodities. These assumptions include:

- Shifts in consumer preferences towards organic produce revealed by consumer willingness to pay a premium for organic produce. The shifts in preferences are incorporated through the use of exogenous shifts in intermediate and final demand.

- Shifts in supply curve incurred by increase in production costs associated with organic production.

[1] The commodities and countries used in the model are given in appendix 1.

This is tested against assumptions relating to the proportions of organic consumption and production share in New Zealand (NZ) and its three most important trade partners within organics; Australia (AUS), United States (US), European Union (EU) and Japan (JP). No changes in other countries in the LTEM-model were simulated.

The scenarios were developed to reflect expectations for developments in organic production on basis of the development within organics worldwide. The scenarios are based upon varying four factors relating to the organic market as follows:

A. *Shift in consumer preference towards organic produce.*
   Increased consumer preference towards organic food produce implies willingness to pay an organic food premium. Price premiums for organic products in general vary a lot but most likely the longer term premiums are within the 10-30 percent "boundary".

   Thus three levels of price premiums were used in the model:
   - 0 percent to reflect a situation where organic produce does not attract a premium
   - 10 percent to reflect a low premium for organic produce
   - 30 percent to reflect the higher premium, which is closer to current market premium

B. *Shifts in supply curve due to increase in production costs with organic production.*
   In general, converting from conventional to organic production results in a decrease in production which is equivalent to a shift in the supply curve. European countries, US and JP have similar types of production methods and intensity of production; whereas NZ production is more extensive.

   Thus the scenarios used in this paper are:
   - A zero change in producer costs in NZ, AUS, EU, US and JP
   - 10 percent increase in NZ, AUS, EU, US and JP.

Organic consumption and production rate was modelled at; 5 percent in NZ and 10 percent in US, EU and JP. Reviewing the literature this does imply growth in the organic sector, a more conservative estimate was made for NZ.

Thus in total 6 different scenarios were run. These scenarios reflect both the most likely outcomes of given market development but also some extremes to determine high risk and benefit possibilities.

The scenarios were modelled with the base year 1997, up till 2010. This report presents the 2010 model results by showing the overall effect on organic producer returns for NZ, Australia, US and the EU. These are compared with a base solution of no change in premium or production costs.

Table 3 Changes in producer returns from demand preferences and productivity shifts

	New Zealand		US		EU		Australia	
	No supply shift	10% supply shift	No supply shift	10% supply shift	No supply shift	10% supply shift	No supply shift	10% supply shift
No demand effect	Base	-1.12	Base	-1.20	Base	-1.27	Base	-1.51
10% organic premium	1.96	0.37	1.22	-0.19	2.06	0.48	2.53	0.63
30% organic premium	8.01	1.09	4.29	1.90	7.25	3.54	9.26	4.54

These results show that assuming 5 per cent organic production and consumption in NZ and 10 per cent in the rest of the world a10 per cent price premium increases total producer returns by between 1.2 and 2.53 per cent. A 30 per cent premium for organic products increases returns by over 4 per cent in the US and by over 7 per cent in the EU. However, a 30 per cent premium increases returns by 8 and 9 per cent in NZ and Australia respectively.

In case of increase in producer costs for organic production and assuming no price premium, there is a fall in producer returns. An increase in production costs even with a 10 per cent price premium for organics also leads to a fall in producer returns in the US and a small increase in returns in the other countries reported above. A 30 per cent price premium and 10 per cent increase in producer costs does lead to an increase in returns but by only 1 per cent in NZ. Thus impact on sector does seem sensitive to producer cost differentials.

4. Further research

To expand and improve modelling further information is required about the different costs and benefits of organic versus conventional production. A six year programme in NZ is assessing in detail the economic, social and environmental issues at the farm level between organic, conventional and/or integrated production, (ARGOS – Agricultural Research Group on Sustainability). This is initially concentrating upon the sheep and beef and kiwi fruit sectors but also expanding into dairy and the NZ high country pastoral leases.

Initial results from the sheep and beef farms suggest that there maybe differences in cost of production. The initial results also indicate differences in resource configuration (production factors) that may well have impact on the economics and dynamics of agriculture. However, these differences are not statistically significant and concern exists given high standard deviation within the farm groups.

These results are illustrated in figures 4 and 5 which show the expenditure and revenue per hectare.

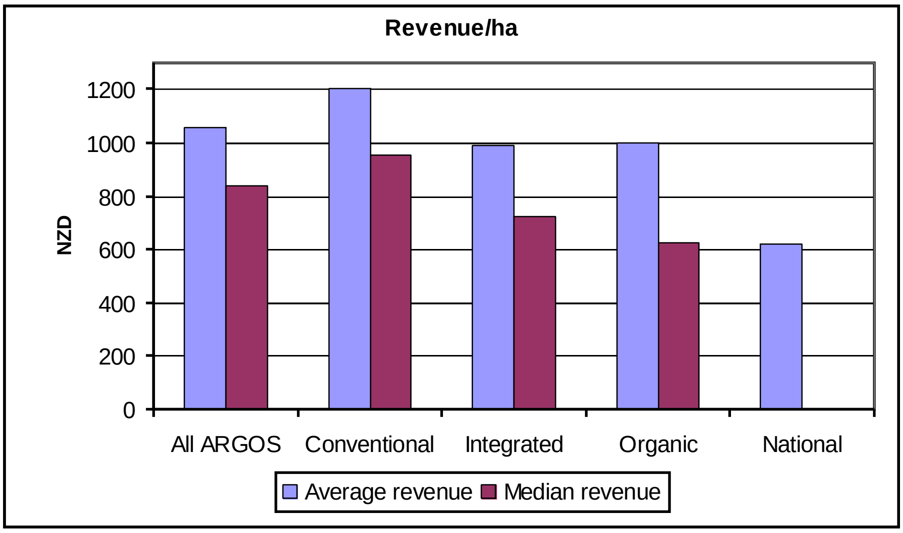


Figure 4 Revenue per hectare and cash farm expenditure per hectare for sheep and beef farms in NZ

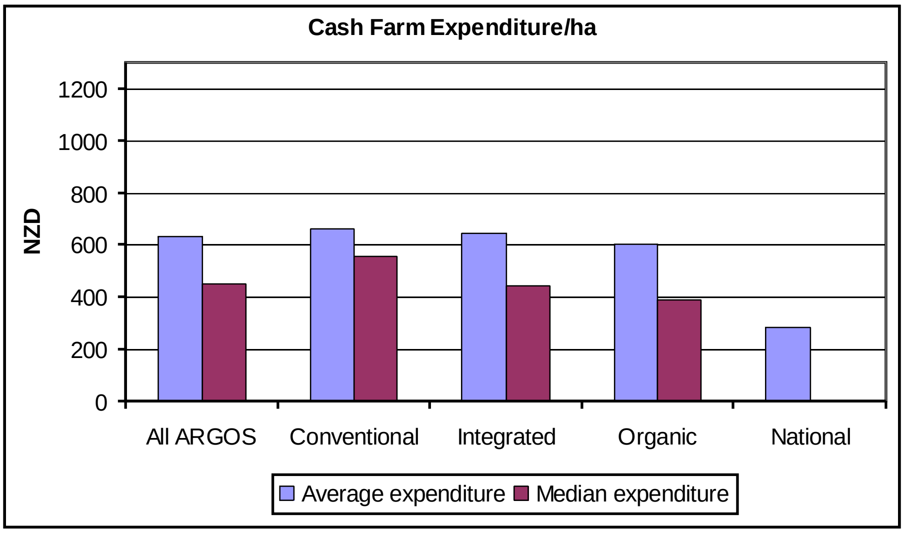


Figure 5 Revenue per hectare and cash farm expenditure per hectare for sheep and beef farms in NZ

In the case of kiwi fruit there are some preliminary results of the differences across farm types, as follows:-

- Cash Orchard Expenditure/ha was approx $5000 less for organic compared to both other systems.
- Wages/ha were approx $4000 less for organic compared to both other systems.
- Fertilisers/ha were approx $650 more for organic compared to Hayward Kiwigreen.
- Repairs and Maintenance are approx $1600 less for organic compared to Hayward Kiwigreen.

These data when further analysed will provide information on relative production costs between organic and other production systems which will enable the model specification to be altered and further scenarios run.

5. Conclusion

The aim of this study has been to explore under what assumptions the development of organic agriculture would be beneficial.

The modelling results show that the countries modelled here might benefit by increasing production of organic commodities. The simulations indicate that given price premiums there are increases to returns, as expected. However, with increase in production costs whilst producer returns fall this is insignificant however it does reduce the benefits of the price premiums, again as expected. This does show the sensitivity of returns to increased production costs.

References

Agra Europe 2004, 23 Dec, 'Danish organic production set to fall', *Agra Europe weekly*, N/3.

BIOGRO 2004, '*Market information'*, retrieved 13 Jan 2005, from http://www.bio-gro.co.nz/

Cagatay, S., and Saunders, C. 2003, '*Lincoln Trade and Environment Model (LTEM): An Agricultural Multi-Country, Multi-Commodity Partial Equilibrium Framework*, research report no. 254, AERU, Lincoln University, Canterbury, New Zealand.

Christensen, V., and Saunders, C. 2003, '*Economic Analysis of Issues Concerning Organic Dairy Farming', research report no.* 257, AERU, Lincoln University, Canterbury, New Zealand.

Connolly, L. 2002, '*Costs and margins in organic production in comparison with conventional production'*, paper presented at the Rural Development Conference 2002, Tullamore Court Hotel.

EISFOM 2004, '*Certified and policy-supported organic and in-conversion land area (ha) in the enlarged European Union,'* retrieved 13 Jan 2005, from www.eisfom.org/press/may04fig.pdf

Elliott, J., Temple, M. L., Clinton, S., Tiffin, A. L., Rees, E., and Standen, J. 2003, '*Evidence assessment to inform the review of the organic farming scheme'*, ADAS Consulting Ltd and University of Reading, Department of Agricultural and Food Economics, London.

Fonterra Co-operative Group 2004, '*Annual Report 03/04'*, (No. 03/04), Auckland, New Zealand.

Hamm, U., Gronefeld, F., and Halpin, D. 2002, '*Analysis of the European market for organic food*', School of Management and Business, Wales, United Kingdom.

La Via, G., and Nucifora, A. M. D. 2002, 'The determinants of the price mark-up for organic fruit and vegetable products in the European union', *British Food Journal*, vol. 104(3-5), pp. 319-336.

Lohr, L. 2001, '*Factors affecting international demand and trade in organic food product'*, retrieved 14 Jan 2005, from http://www.ers.usda.gov/publications/wrs011/wrs011j.pdf

Mason, S. 2002, 'New Zealand organic dairy production', in V. L. Christensen (Ed.) (pp. e-mail): BIOGRO Chief Executive Officer.

Millock, K., and Hansen, L. G. 2002, '*Willingness to pay for organic foods: A comparison between survey data and panel data from Denmark*', retrieved 13 Jan 2005, from http://orgprints.org/1754/

Ministry of Agriculture and Forestry 2002, '*Understanding the costs and risks of conversion to organic production systems'*, no. 2002/1, Wellington.

OPENZ 2002, '*New Zealand Organic Exports 2001-2002*', retrieved 14 Jan 2005, from http://www.organicsnewzealand.org.nz/documents/organicexports2001-02.htm

Organic Trade Services 2005, '*Market Overview*', retrieved 20 Jan 2005, from http://www.organicts.com/

Saunders, C., Manhire, J., Campbell, H., and Fairweather, J. 1997, '*Organic Farming in New research needs'*, no. 97/13, Wellington, New Zealand.

Shadbolt, N., Kelly, T., and Holmes, C. 2004, '*Organic Dairy Farming: Cost of Production and Profitability'*, paper presented at the 2004 AFBMNetwork Conference, Australia.

Smith, E., and Marsden, T. 2003, '*Exploring the "Limits to Growth" in UK Organics: Beyond the Statistical Image*', Cardiff University, Cardiff.

Soil Association 2004, '*Key data about the organic food and farming sector 2004*', retrieved 11 Jan 2005, from http://www.soilassociation.org/web/sa/saweb.nsf/home/index.html

Teagasc 2004, '*Guidelines for Organic Farming*', retrieved 13 Jan 2005, from http://www.teagasc.ie/publications/2003/organicfarming/organicfarmingguidelines.htm

USDA Foreign Agricultural Service 2004, '*Swedish Market for Organic Products 2004*', retrieved 12 Jan 2004, from http://www.fas.usda.gov/gainfiles/200409/146107434.pdf
Willer, H., and Yussefi, M. (eds.) 2004, '*The World of Organic Agriculture – Statistics and Emerging Trends – 2004* (6 ed.)', International Federation of Organic Agriculture Movements, Bonn.
Yussefi, M., and Willer, H. (eds.) 2003, '*The World of Organic Agriculture - Statistics and Future Prospects - 2003* (5 ed.)', Tholey-Theley: International Federation of Organic Agriculture Movements.

Appendix 1 LTEM Model

The countries/regions included in the model are:

Argentina (AR)
Australia (AU)
Canada (CN)
Europe (EU) – 15 nations
Japan (JP)
Mexico (MX)
New Zealand (NZ)
United States (US)
Rest of the World (RW)

The commodities included in the model are:

Wheat (WH)
Coarse Grain (CG)
Maize (MZ)
Oilseeds (OS)
Oilseeds meals (OM)
Oils (OL)
Beef (VL)
Sheep Meat (SM)
Milk, farm (MK) - assumed not traded
Milk, liquid & other products (ML) – assumed not traded
Butter (BT)
Cheese (CH)
Whole milk powder (MW)
Skim milk powder (MS)
Apples (AP)
Kiwi fruit (KW)

The above listing is separated into those commodities that are produced conventionally and those produced organically.

Appendix 2 Model equations.

LTEM is a dynamic framework since it provides the time paths of endogenous variables within a short to medium-term time horizon. Basically, the model works by simulating the commodity based world market clearing price on the domestic quantities and prices, which may or may not be under the effect of policy changes[1], in each country. Excess domestic supply or demand in each country spills over onto the world market to determine world prices. The world market-clearing price is determined at the level that equilibrates the total excess demand and supply of each commodity in the world market by using a non-linear optimisation algorithm[2]. The general equation structure of each commodity at country level in LTEM is represented by eight behavioural equations and one economic identity as the in the equations 1 to 9.

$$pt_{ij} = f\,(WDpt_i, ex_j) \quad (1)$$
$$pp_{ij} = g\,(pt_{ij}, Zsp_j,) \quad (2)$$
$$pc_{ij} = h\,(pt_{ij}, Zdp_j) \quad (3)$$
$$qs_{ij} = l\,(pp_{ij}, pp_{ijk}, pp_{ij,\,org}, ssft_{ij}, Zsq_j) \quad (4)$$
$$qd_{ij,\,fo} = m\,(pc_{ij}, pc_{ijk}, pp_{ij,\,org}, dsft_{ij,\,fo}, pinc_j, pop_m) \quad (5)$$
$$qd_{ij,\,fe} = m'\,(pc_{ij}, pc_{ijk}, pp_{ij,\,org}, qp_{dairy,\,j}, dsft_{ij,\,fe}) \quad (6)$$
$$qd_{ij,\,pr} = m''\,(pc_{ij}, pc_{ijk}) \quad (7)$$
$$qst_{ij} = n\,(qs_{ij}, pc_{ij}, stsft_{ij}) \quad (8)$$
$$qt_{ij} = qs_{ij} - (qd_{ij,\,fo} + qd_{ij,\,fe} + qd_{ij,\,pr}) - \Delta qst_{ij} \quad (9)$$

The trade price (pt) of a commodity ($_i$) in country ($_j$) is determined as a function of world market price ($WDpt_i$) of that commodity and the exchange rate (ex_j). The total effect of world market price on trade price of the country is determined by the price transmission elasticity [equation 1].

Domestic producer (pp_{ij}) and consumer (pc_{ij}) prices are defined as functions of commodity i's trade price (pt_{ij}) , the commodity specific production and consumption related domestic support/subsidy policies and tariffs (Zsp_j and Zdp_j) [equation 2 and 3].

The domestic supply and demand equations are specified as constant elasticity functions that incorporate both the own and cross-price effects.

Supply (qs_{ij}) is specified as a function of producer prices of the own (pp_{ij}), other substitute and complementary (pp_{ijk}) commodities and a supply shifter ($ssft_{ij}$), which represents economic factors that may cause shifts in supply. In addition to a policy variable (Zsq_j) that reflects production related policies/tariffs and the supply equation is specified to include the cross-price ($pp_{ij,\,org}$) effect of conventional and organic products on each other [equation 4].

Total demand is separated into food ($qd_{ij,\,fo}$), feed ($qd_{ij,\,fe}$) and processing industry ($qd_{ij,\,pr}$) demand.

[1] LTEM allows the application of various domestic and border policies explicitly such as production quotas, set-aside policies, input and/or output related producer subsidies/taxes, consumer subsidies/taxes, minimum prices, import tariffs and quotas, export subsidies and taxes.

[2] Solver: Is a mathematical equation called Newton's global or search algorithm.

Food demand ($qd_{ij,\ fo}$) is specified as a function of consumer prices of own (pc_{ij}), other substitute and complementary (pc_{ijk}) commodities. The demand equation is specified to include the cross-price ($pp_{ij,\ org}$) effect of conventional and organic products on each other and a demand shifter ($dsft_{\ ij,\ fo}$) representing economic factors that may cause shifts. Furthermore a per capita real income ($pinc_j$) variable in the economy and growth in population (pop_m) are included [equation 5].

Feed demand ($qd_{ij,\ fe}$) is defined as a function of pc_{ij} and pc_{ijk}, the cross-price ($pp_{ij,\ org}$) effect of conventional and organic products on each other, the extent of dairy production ($\mathrm{qp}_{\mathrm{dairy},\ \mathrm{j}}$) and a demand shifter ($dsft_{\ ij,\ fe}$) [equation 6].

Processing industry demand ($qd_{ij,\ pr}$) is defined as a function of pc_{ij} and $pc_{ijk.}$ In addition, food and feed demand functions also incorporate cross-price effect of conventional and organic products on each other [equation 7].

The stocks (qst_{ij}) are determined as a function of quantity supplied (qs_{ij}), consumer price (pc_{ij}) and a stock shifter ($stsft_{ij}$) [equation 8]. There is no stock demand for raw and liquid milk. It is assumed that raw milk is stocked in the form of butter, cheese and/or milk powder.

Finally net trade (qt_{ij}) of the country ($_j$) in commodity ($_i$) is determined as the difference between (domestic) supply and sum of (domestic) demand components and stock changes in the related year [equation 9]. Since it is assumed that all produced raw milk is utilised in the form of processed products, raw milk is not traded in LTEM.