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Dairy product production and lactose demand in New Zealand and Ireland under different simulated milk product–processing portfolios

N.W. Sneddon[1†], N. Lopez-Villalobos[1], R.E. Hickson[1], S.R. Davis[2], U. Geary[3], D.J. Garrick[1], L. Shalloo[3]

[1]Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand
[2]Livestock Improvement Corporation, Private Bag 3016, Hamilton 3240, New Zealand
[3]Dairy Production Department, Teagasc, Moorepark Production Research Centre, Fermoy, County Cork, Cork, Ireland

Abstract

Maximising dairy industry profitability involves maximising product returns for a specific set of costs or minimising costs for a certain level of output. A strategy currently utilised by the New Zealand dairy industry to optimise the value of exports is to incorporate imported lactose along with local milk to maximise the production of whole milk powder (WMP) while complying with the Codex Alimentarius (Codex) standards, in addition to increasing the exported product for every litre of milk. This study investigated the impact of different product portfolio strategies on lactose requirements for the Irish and New Zealand dairy industries for current and predicted 2020 milk output projections. A mass balance processing sector model that accounts for all inputs, outputs and losses involved in dairy processing was used to simulate the processing of milk into WMP, skim milk powder (SMP), cheese, butter and fluid milk of different proportions. All scenarios investigated projected an increase in production and revenue from 2012 to 2020. Higher cheese production reduced industry lactose demand through whey processing, while scenarios reliant on an increase in the proportion of WMP were associated with increased lactose deficits.

Keywords

Ireland • lactose demand • New Zealand • processing model

Introduction

The dairy industries of both New Zealand and Ireland are limited by the land area available for dairy expansion where cows can access feed within a reasonable walking distance from a milking shed. The limits of land area are due to geographical (such as topography and soil types) and climatic factors, as well as social and political restrictions. The New Zealand dairy industry is reaching its limit for pastoral dairying, with 15% of land originally classified as arable farmland now used in dairying (Livestock Improvement Corporation [LIC] and DairyNZ, 2014; World Bank, 2014), and is facing increased feed costs; with imported feeds increasing as a proportion of the total diet, while reducing the resilience of the overall dairy industry. The European Union (EU) milk quota regime ceased for the EU and Irish dairy industries on 31st March 2015, allowing for potential expansion at the farm level, for the first time in a generation, for many. Dairy farm profitability will be determined by the most limiting resource, which, on most farms, will be land area.

Profitability at the dairy industry level is maximised when the output of the most profitable products is prioritised across a supply profile that balances costs at both farm and processor levels. The optimisation process centres on maximising product returns (including by-products) after accounting for costs and making the most of the available local resources. The purchase of additional milk components, such as lactose, as ingredients beyond raw milk may increase the yields of the manufactured products. The associated increases in ingredient costs are only justified if they are less than the increased value of the final product after accounting for the processing costs. In any scenario, the composition of the manufactured dairy products must remain within market requirements and Codex Alimentarius (Codex) standards (Codex standard 207-1999; World Health Organization [WHO]/Food and Agriculture Organization [FAO], 2011).

In New Zealand, in the past, milk was standardised by removing excess fat and protein and selling it separately, while over the past 10 years, there has been an increasing trend of importing lactose to extend the yield of whole milk powder (WMP). There is a requirement to meet a set of international Codex requirements (Codex standard 207-1999; WHO/FAO, 2011). Milk from the New Zealand dairy herd is deficient in lactose relative to fat and protein when manufactured into WMP, which limits the complete

†Corresponding author: N.W. Sneddon
E-mail: n.w.sneddon@massey.ac.nz

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utilisation of fat and protein during the manufacture of WMP (Sneddon *et al*., 2014). Processors can either purchase lactose or utilise the excess protein and/or fat in the form of less-valuable products or change their product portfolio. In Ireland, this has not occurred to date because lactose has not been in deficit. However, it is anticipated that post-quota, there will be dairy expansion and much of the additional milk will be processed into WMP, which may create situations in which lactose is limited, as a greater proportion of milk is allocated to WMP production.

The objective of this study was to investigate the impact of different product portfolios for Irish and New Zealand dairy industries in terms of lactose demand considering the current and anticipated milk constituents, as well as the current and future product portfolios across a range of input costs and output prices.

Materials and methods

Model description

A more detailed description of the model functionality and methodology is available in the study by Geary *et al*. (2010). This processing-sector model accounts for all inputs, outputs and losses involved in dairy processing (Geary *et al*., 2010), which was used in this study to simulate the standardisation and processing of WMP, SMP, cheese, butter and fluid milk from milk purchased from the farm. Key inputs for the model were volume and composition of milk, as well as product portfolio and its composition. The quantities of products and by-products that can be produced from the available milk pool by balancing the inputs of fat and protein are calculated (Geary *et al*., 2010). The model balanced the fat and protein quantities, to identify lactose deficits or surpluses when producing product to current Codex standards.

For the purposes of this study, additional economic calculations at the processor level were completed using model outputs. These were the calculations of gross income (as product yields multiplied by product values) and net revenue (as gross income minus processing costs of each product). Values for each product were estimated from the Global Dairy Trade (GDT, 2013) historical data for the 2011/2012 dairy season for the current and future scenarios, while the manufacturing costs were from Geary *et al*. (2010). Market values from July 2008 to May 2016 are presented in Figure 1, wherein vertical lines designate the periods in which the prices were sampled.

Processor returns

Gross revenues were calculated as the sum of all product outputs multiplied by their respective market values. Lactose costs were calculated as the price of lactose multiplied by the

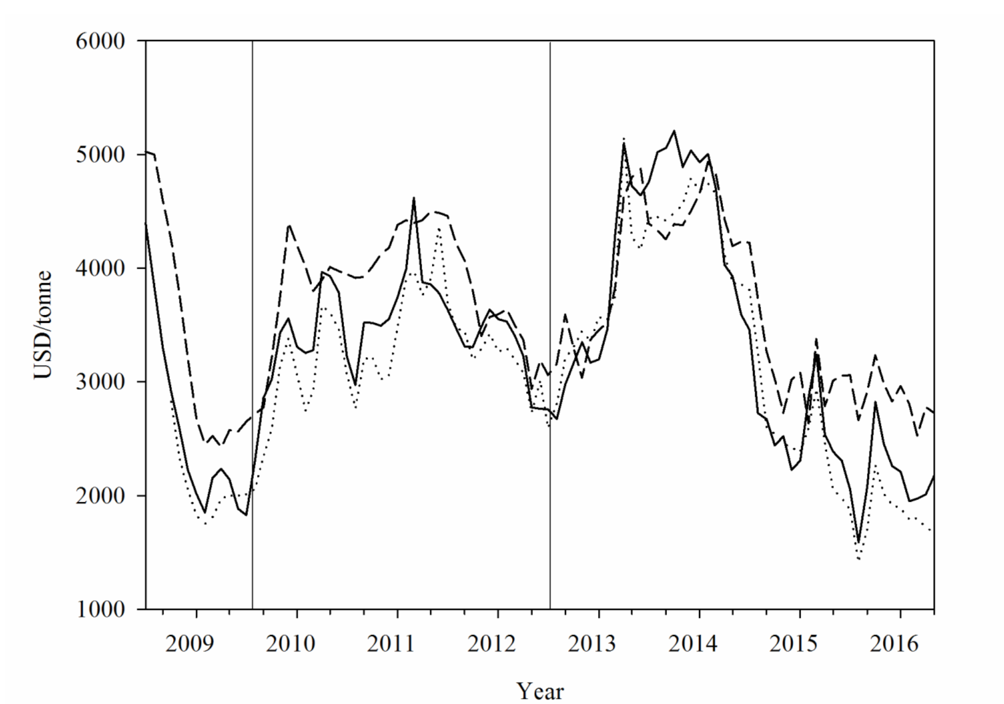

Figure 1. Market values for whole milk powder (—), skim milk powder (·······) and cheese (- - - -) from July 2008 to May 2016. Vertical lines show the period in which values were sampled for modelling purposes.

size of the lactose-processing deficit in tonnes. Net revenues were the sum of gross revenue of each product minus the collective processing costs and cost to purchase additional lactose as an ingredient.

Economic calculations were based on outputs from the Moorepark Processing Sector Model (MPSM) (Geary *et al.*, 2010) and dairy product prices (in US$) for WMP, SMP, cheese, butter, butter milk powder (BMP), casein and milk protein concentrate (MPC) 70 (MPC70) (used as a proxy for MPC90) from the GDT auction from 1st June 2011 to 15th May 2012 (GDT, 2013). The price for whey powder (WP) was not available from the GDT, so it was based on the average price for 2012 of €917.5/t (Productschap Zuivel, 2013), converted to US$1,241.54/t using the average 2012 exchange rate of US$1.35 per euro (NZForex, 2013). All values in Table 1 are in US$ as this is the common currency of GDT; all values were converted to US$ based on this exchange rate.

Costs

Costs for production of each tonne of product are shown in Table 1. These costs were converted to US$ from those in Geary *et al*. (2010) using the same conversion factor as for product prices. Costs for MPC90 and casein were assumed to be equal to the cost of manufacture of WP due to similarities in processing requirements, and lactose recovery was assumed to be equal to half the cost of WP production due to a lower drying requirement. Costs were calculated per tonne per product (with the costs for addition of lactose included) and summed to estimate the total costs.

Data

Product composition was assumed to be based on the international Codex standards as in Geary *et al*. (2010) and Table 2. Milk production (total in litres) and composition (milk fat, protein and lactose concentrations) for both Ireland and New Zealand are shown in Table 3. In order to complete the current and future scenarios, a range of scenarios were considered based on current national situations and projected future 2020 milk output circumstances for Ireland and New Zealand, accounting for expected gains in these two dairy industries.

Irish scenarios

Data for the Irish baseline were obtained from the Central Statistics Office (CSO) (2013), as well as Geary *et al*. (2012, 2014), which provided milk volume (in litres) and concentrations of milk fat, protein and lactose. These were average concentrations per month for the 2012 season; the weighted annual average was calculated for use in the MPSM. For Ireland, the production in 2020 was estimated based on an increase in milk output by 50%, as an approximation of the 47% projected by Laepple and Hennessy (2012), equating to approximately 7.5 billion litres of milk (Shalloo, 2013; personal communication). Milk fat and protein concentrations were assumed to increase at rates of 0.016% and 0.008% per year, respectively, based on historical changes (CSO, 2013), while lactose concentration was assumed to remain stable. Production for 2012 and estimated 2020 seasons are shown in Table 3.

Table 1. Market values and processing costs of dairy products in different years used in the model for sensitivity analysis

Year	US$/t of product[1]								
	WMP	SMP	Cheese	Butter	Casein	MPC	WP	BMP	Lactose
2012	3,355.39	3,292.63	3,454.51	3,994.00	8,185.59	5,549.36	1,241.54	3,133.10	1,979.27
2011	3,605.00	3,321.00	4,168.00	4,344.00	10,519.00	6,148.00	1,157.35	3,133.10	–
2010	3,215.00	3,953.00	3,679.00	3,539.00	8,782.00	5,197.00	922.73	3,042.00	–
Processing cost	496.95	465.75	449.50	441.25	572.05	572.05	572.05	429.30	286.00

[1]WMP = whole milk powder; SMP= skim milk powder; MPC = milk protein concentrate; WP = whey powder; BMP = butter milk powder; US$ = American dollar.

Table 2. Composition of dairy products (in g/100 g) of final products in Ireland and New Zealand

Component	Product[1]							
	WMP	SMP	Cheese	Butter	Casein	MPC	WP	BP
Fat	26.50	1.00	35.00	84.00	0.00	0.00	1.00	8.30
Protein	25.10	33.00	24.50	0.59	89.00	90.50	15.15	41.72
Lactose	39.80	54.00	1.39	0.79	0.56	Trace	77.15	40.32
Minerals	5.90	8.00	2.15	0.12	0.80	Trace	4.32	4.66
Water	2.70	4.00	35.26	14.50	9.64	9.50	2.38	5.00

[1]WMP = whole milk powder; SMP = skim milk powder; MPC = milk protein concentrate; WP = whey powder; BMP = butter milk powder.

Product mixes used for each of the scenarios for both Ireland and New Zealand are shown in Table 4. Product mixes were chosen to reflect five possible product portfolios. In the Irish baseline scenario (Scenario Ire-1), the milk production and product mix from 2012 was assumed, and Irish Scenarios Ire-2 to Ire-6 reflect using 100%, 75%, 50%, 25% and 0% of the additional milk available in 2020 in the production of WMP, with the balance processed into cheese. In scenarios wherein there was excess protein from the production of SMP, this was processed into MPC90.

New Zealand scenarios

Data for the New Zealand baseline scenario were obtained from Dairy Companies Association of New Zealand (DCANZ) (2013), in terms of milk volume (litres) for each month of the 2011/2012 dairy season. Milk fat and protein production data were obtained from New Zealand dairy statistics (LIC and DairyNZ, 2012). Lactose percentage was estimated from a national dataset obtained from LIC (unpublished data). The weighted annual average concentrations were calculated from these monthly average figures for use in the MPSM.

Table 3. Baseline 2012 dairy industry production[1] and estimated future production (based on current rate of expansion for New Zealand[2] and Irish expansion post quota) figures for Ireland and New Zealand

Country	Milk (billion litres)	Fat (%)[3]	Protein (%)[3]	Lactose (%)[3]
Ireland 2012	5.376	3.94	3.37	4.61
Ireland 2020	7.500	4.08	3.43	4.61
New Zealand 2012	19.742	4.96	3.90	4.95
New Zealand 2020	26.220	5.03	3.98	4.95

[1]Livestock Improvement Corporation (LIC) and DairyNZ (2012); Central Statistics Office (2013); Dairy Companies Association of New Zealand (2013).
[2]LIC and DairyNZ (2012).
[3]Percentage presented as g/100 g of milk; lactose concentration measured as lactose monohydrate.

Table 4. Proportion (%) of total milk processed into each product stream in initial modelling before post-modelling modification for NZ Scenarios 3 and 5

Scenario[2]	Product[1]				
	WMP	SMP	Cheese	Butter	Casein
Irish base (Scenario Ire-1)	13.0	17.5	38.0	31.5	–
Irish Scenario Ire-2	37.65	12.5	25.25	22.6	–
Irish Scenario Ire-3	30.5	12.5	34.4	22.6	–
Irish Scenario Ire-4	23.5	12.5	41.4	22.6	–
Irish Scenario Ire-5	16.4	12.5	48.5	22.6	–
Irish Scenario Ire-6	9.3	12.5	55.6	22.6	–
New Zealand (NZ) base (Scenario NZ-1)	60.0	23.5	14.0	0.5	2.0
NZ Scenario NZ-2	60.0	23.5	14.0	0.5	2.0
NZ Scenario NZ-3	60.0	23.5	14.0	0.5	2.0
NZ Scenario NZ-4	69.5	18.0	10.5	0.5	1.5
NZ Scenario NZ-5	60.0	23.5	14.0	0.5	2.0
NZ Scenario NZ-6	13.95	5.46	80.0	0.11	0.48

[1]WMP = whole milk powder; SMP = skim milk powder.
[2]Irish baseline (Scenario Ire-1) is 2012 season milk and product mix; Irish Scenario Ire-2 is 100% of post-quota milk into WMP; Scenario Ire-3 is 75% of post-quota milk into WMP with 25% into cheese; Scenario Ire-4 is 50% of post-quota milk into both WMP and cheese; Scenario Ire-5 is 25% of post-quota milk into WMP with 75% into cheese; Scenario Ire-6 is 100% of post-quota milk into cheese. New Zealand (NZ) base (NZ Scenario NZ-1)is 2012 season milk and estimated product mix; NZ Scenarios NZ-2, NZ-3 and NZ-5 have the same initial product mix as the base with 2020 estimated milk production; Scenario NZ-2 is 2020 production with 2012 portfolio; Scenario NZ-3 is back-calculated to have no lactose deficit, with excess fat and protein going into butter and casein, respectively; Scenario NZ-4 is 100% of increased milk production into WMP; Scenario NZ-5 is back-calculated to recover 80% of lactose from cheese whey to be incorporated into WMP; Scenario NZ-6 is 80% of total milk production into cheese.

For the estimation of 2020 milk production, it was assumed that milk production would continue to increase at 4% per year, as estimated using data from NZ Dairy Statistics (LIC and DairyNZ, 2012), with milk fat and protein concentrations increasing at rates of 0.006% and 0.008% per year, respectively (LIC and DairyNZ, 2012). Production parameters for the current base and predictions for 2020 are shown in Table 3. The product portfolios were estimated from several sources, including the Fonterra Annual Report 2012 (Fonterra, 2012a), Fonterra Farmgate Milk Price statement (Fonterra, 2012b) and Fonterra Milk Price – the Facts (Fonterra, 2012c), all of which were used to compile an estimated product portfolio.

The product mix for each scenario is shown in Table 4. The New Zealand current production (Scenario NZ-1) was based on the 2011/2012 dairy season data (DCANZ, 2013). Scenario NZ-2 simulates the impact of using 2020 milk production with the actual 2012 product portfolio. In Scenario NZ-3, the production of WMP was adjusted to balance the available lactose, with excess fat and protein used for butter and casein production, respectively, complying with Codex standards without importing lactose. Scenario NZ-4 used all the predicted increase in milk production to produce WMP with imported lactose. Scenario NZ-5 achieved lactose recovery of 80% from whey by ultrafiltration at efficiencies similar to levels reported in industry publications (Archer, 1998; Mollea *et al*., 2013), with MPC being produced from the remaining WP. Scenario NZ-6 assumed that 80% of the additional milk was converted into cheese, with the remaining increase converted to WP production.

- Scenario NZ-1: Actual 2012 milk production with 2012 product portfolio
- Scenario NZ-2: Predicted 2020 milk production with 2012 product portfolio
- Scenario NZ-3: Predicted 2020 milk production, no external lactose incorporated, excess fat and protein incorporated into butter and MPC
- Scenario NZ-4: Predicted 2020 milk production, increased milk production for WMP production with imported lactose
- Scenario NZ-5: Predicted 2020 milk production with 2012 product portfolio, with lactose recovery from WP and with deficit filled with imported lactose
- Scenario NZ-6: Predicted 2020 milk production, 80% of milk diverted towards cheese production

The model was run with the same product portfolios for scenarios NZ-2, NZ-3 and NZ-5. From the resulting model outputs in Scenario NZ-3, fat and protein were removed until the balance was achieved for lactose (giving no imported lactose), excess fat was incorporated into butter and excess protein was incorporated into MPC90. In Scenario NZ-5 (lactose recovery from WP), it was assumed that ultrafiltration of whey would yield 80% (Archer, 1998; Mollea *et al*., 2013) of the total lactose content as lactose powder, with the remainder being incorporated into the WP production process. The recovered lactose was subtracted from the lactose deficit from WMP to reduce the total lactose deficit in the system.

Sensitivity analysis

To analyse the effects of product prices on net revenues, average product prices from 2010, 2011 and 2012 were utilised (Fonterra, 2012b; CLAL, 2013; DairyCo, 2013a, 2013b; GDT, 2013; Productschap Zuivel, 2013). These values are shown in Table 1. These numbers were used to compare between three different pricing scenarios in which the values of cheese and WMP were differentiated.

Results

Product outputs for the Irish scenarios are shown in Table 5 and those for the New Zealand scenarios in Table 6. Milk output and product outputs are greater in New Zealand than in the Irish scenarios due to the significant differences in the size of the industries in each country. Comparisons between the two industries on key traits common to both industries were completed. Based on 2012 production levels, New Zealand proportionally processed four and a half times as much of its milk (54.2%) into WMP compared with Ireland (11.7%), whereas Ireland allocated almost twice as much milk into SMP and cheese, in addition to making almost three times as much WP compared to New Zealand.

It was predicted that by 2020, milk production in New Zealand will rise to 26.2 billion litres based on a compound growth of 4% per year, with milk fat and protein concentrations increasing to 5.03% and 3.98%, respectively. For Ireland, post quota, the industry goal is a 50% increase in milk volume, taking Irish milk production to approximately 7.5 billion litres of milk, with milk fat and protein concentrations increasing to 4.08% and 3.43%, respectively.

When evaluated on the total yields of products, SMP, butter, MPC90 and BMP did not vary much between the Irish scenarios. However, the volumes of WMP, cheese and WP varied from scenarios Ire-2 to Ire-6 as the use of post-quota milk shifted from WMP to cheese. Cheese and WP production were similar to the baseline state in Scenario Ire-2, and WMP yield was similar to baseline in Scenario Ire-6.

Gross revenue from model outputs for Ireland is presented in Table 7. Based on expected 2020 milk production and average 2012 (GDT, 2013; Productschap Zuivel, 2013) product price assumptions for Ireland, the greatest gross revenue would be achieved with 100% of post-quota milk going into WMP production. This would see the production of 290,000 t more of WMP compared with 2012 and an increase of US$1.1 billion in gross revenue. The difference in gross revenue between scenarios of 100% of additional milk going into WMP compared

Table 5. Tonnes (,000) of product produced from modelling alternative scenarios for Ireland

Scenario[2]	Product[1]							
	WMP	SMP	Cheese	Butter	MPC90	WP	BMP	Lactose deficit
Scenario Ire-1	93	212	227	124	15.1	114	14	–5
	(11.7)	(26.4)	(28.4)	(15.6)	(1.9)	(14.3)	(1.7)	
Scenario Ire-2	383	211	231	141	16.7	114	14	–23
	(34.4)	(19.0)	(20.8)	(12.7)	(1.5)	(10.3)	(1.3)	
Scenario Ire-3	310	211	292	138	16.7	144	16	–19
	(27.5)	(18.7)	(25.9)	(12.3)	(1.5)	(12.8)	(1.4)	
Scenario Ire-4	239	211	351	135	16.7	174	14	–14
	(20.9)	(18.5)	(30.8)	(11.9)	(1.5)	(15.2)	(1.2)	
Scenario Ire-5	166	211	411	132	16.7	204	15	–10
	(14.4)	(18.2)	(35.6)	(11.4)	(1.5)	(17.6)	(1.3)	
Scenario Ire-6	95	211	472	129	16.7	234	15	–6
	(8.1)	(18.0)	(40.3)	(11.0)	(1.4)	(20.0)	(1.2)	

Values in parentheses are the contribution (%) of that product to the national product portfolios.
[1]WMP = whole milk powder; SMP = skim milk powder; MPC90 = milk protein concentrate 90% protein; WP = whey powder; BMP = butter milk powder.
[2]Scenario Ire-1 is 2012 season milk and product mix; Scenario Ire-2 is 100% of post-quota milk into WMP; Scenario Ire-3 is 75% of post-quota milk into WMP, with 25% into cheese; Scenario Ire-4 is 50% of post-quota milk into both WMP and cheese; Scenario Ire-5 is 25% of post-quota milk into WMP, with 75% into cheese; Scenario Ire-6 is 100% of post-quota milk into cheese.

Table 6. Tonnes (,000) of product produced from modelling alternative scenarios for New Zealand

Scenario[2]	Product[1]								
	WMP	SMP	Cheese	Butter	Casein	MPC90	WP	BMP	Lactose deficit
Scenario NZ-1	1,774	494	347	429	12	–	165	54	–129
	(54.2)	(15.1)	(10.6)	(13.1)	(0.4)		(5.0)	(1.6)	
Scenario NZ-2	2,400	666	469	566	17	–	219	71	–271
	(54.5)	(15.1)	(10.6)	(12.8)	(0.4)		(5.0)	(1.6)	
Scenario NZ-3	1,926	532	469	691	–	136	219	71	0
	(47.6)	(13.2)	(11.6)	(17.1)		(3.4)	(5.4)	(1.8)	
Scenario NZ-4	2,780	513	352	507	13	–	164	64	–282
	(63.3)	(11.7)	(8.0)	(11.5)	(0.3)		(3.7)	(1.5)	
Scenario NZ-5	2,400	666	469	565	17	–	91[3]	71	–131
	(56.1)	(15.6)	(11.0)	(13.2)	(0.4)		(2.1)	(1.7)	
Scenario NZ-6	558	155	2,682	184	4	–	1,251	21	–43
	(11.50)	(3.2)	(55.2)	(3.8)	(0.1)		(25.8)	(0.4)	

Values in parentheses are the contributions (%) of that product to the national product portfolios.
[1]WMP = whole milk powder; SMP = skim milk powder; MPC90 = milk protein concentrate 90% protein; WP = whey powder; BMP = butter milk powder. WP has had 80% of lactose removed, making it 13.6% fat, 30.1% protein, 38.5% lactose, 13.1% minerals and 4.6% water.
[2]Scenario NZ-1 is 2012 season milk and estimated product mix; Scenarios NZ-2, NZ-3 and NZ-5 have the same initial product mix as the base with 2020 estimated milk production; Scenario NZ-2 is 2020 production with 2012 portfolio; Scenario NZ-3 is back-calculated to have no lactose deficit, with excess fat and protein going into butter and casein, respectively; Scenario NZ-4 is 100% of increased milk production into WMP; Scenario NZ-5 is back-calculated to recover 80% of lactose from cheese whey to be incorporated into WMP; Scenario NZ-6 is 80% of total milk production into cheese.

with 100% into cheese was estimated to be approximately US$37 million (US $3,622,508,000 versus US$3,585,139,000). Under New Zealand product scenarios, WMP production was maximised in Scenario NZ-4 (all increased milk to WMP) and minimised in Scenario NZ-6 (80% of additional milk processed into cheese). Cheese production was greatest in Scenario NZ-6, but it was similar among Scenarios NZ-2, NZ-3 and NZ-5 as well as between Scenarios NZ-1 and NZ-4.

Gross revenues from the model outputs for New Zealand are presented in Table 8. Using the New Zealand 2020 production

Table 7. Gross revenue (millions, US$) using 2012 market values from model outputs for Irish scenarios

Scenario[2]	Product[1]							
	WMP	SMP	Cheese	Butter	MPC90	WP	BMP	Gross revenue
Scenario Ire-1	313	694	785	497	84	142	43	2,558
Scenario Ire-2	1,285	694	799	565	93	142	45	3,623
Scenario Ire-3	1,041	694	1,008	552	93	179	49	3,616
Scenario Ire-4	802	694	1,213	540	93	216	44	3,602
Scenario Ire-5	560	694	1,421	528	93	253	47	3,596
Scenario Ire-6	317	694	1,629	516	93	290	46	3,585

[1]WMP = whole milk powder; SMP = skim milk powder; MPC90 = milk protein concentrate; WP = whey powder; BMP = butter milk powder.
[2]Scenario Ire-1 is 2012 season milk and product mix; Scenario Ire-2 is 100% of post-quota milk into WMP; Scenario Ire-3 is 75% of post-quota milk into WMP, with 25% into cheese; Scenario Ire-4 is 50% of post-quota milk into both WMP and cheese; Scenario Ire-5 is 25% of post-quota milk into WMP, with 75% into cheese; Scenario Ire-6 is 100% of post-quota milk into cheese.

Table 8. Gross revenue (millions, US$) using 2012 market values from model outputs for New Zealand scenarios

Scenario[2]	Product[1]								
	WMP	SMP	Cheese	Butter	Casein	MPC90	WP	BMP	Gross revenue
Scenario NZ-1	5,952	1,625	1,198	1,711	101	–	204	168	10,961
Scenario NZ-2	8,054	2,193	1,622	2,259	137	–	272	223	14,760
Scenario NZ-3	6,463	1,752	1,622	2,761	–	753	272	223	13,846
Scenario NZ-4	9,329	1,690	1,216	2,023	103	–	204	200	14,766
Scenario NZ-5	8,054	2,193	1,622	2,259	137	–	112	223	14,601
Scenario NZ-6	1,873	509	9,266	734	33	–	1,553	66	14,034

[1]WMP = whole milk powder; SMP = skim milk powder; MPC90 = milk protein concentrate; WP = whey powder; BMP = butter milk powder.
[2]Scenario NZ-1 is 2012 season milk and estimated product mix; Scenarios NZ- 2, NZ-3 and NZ-5 have the same initial product mix as the base with 2020 estimated milk production; Scenario NZ-2 is 2020 production with 2012 portfolio; Scenario NZ-3 is back-calculated to have no lactose deficit, with excess fat and protein going into butter and casein, respectively; Scenario NZ-4 is 100% of increased milk production into WMP; Scenario NZ-5 is back-calculated to recover 80% of lactose from cheese whey to be incorporated into WMP; Scenario NZ-6 is 80% of total milk production into cheese.

estimations with baseline 2012 economic product returns, it was estimated the greatest gross revenue would be generated under the scenario in which all extra milk was used for WMP. This reflects the current strategy used in the New Zealand dairy industry. The least gross revenue would be generated when no lactose was imported. The difference in gross revenue between these two scenarios (NZ-3 – no imported lactose; and NZ-6 – 80% of milk used for cheese production) is approximately US$920 million. Due to the restriction in Scenario NZ-3 on importation of lactose for use in WMP, there is only an increase in WMP production of 152,000 t (8% increase) between the baseline 2012 scenario and 2020 no-lactose-imported scenario, despite a 32% increase in total milk volume.

The cost to produce each product was estimated using the production costs of Geary *et al*. (2010) to estimate the financial differences between scenarios for Ireland and New Zealand. Processing costs, lactose costs and net revenues are shown in Table 9.

The difference in net revenue between the highest and lowest gross revenue scenarios (Scenario Ire-2 versus Scenario Ire-6) was US$31 million (US$3,040,953,000 versus US$3,009,604,000) for Ireland. This difference is despite a lactose cost difference of US$32 million between the scenarios. This can be linked to the increased cost of processing cheese and WP relative to WMP. Sensitivity analyses are presented in Table 10. When individual dairy season prices of 2010 and 2011 were included in the analysis, Scenario Ire-6 (55.6% to cheese) became the more profitable option for the dairy industry in 2010 and 2011, compared to Scenario Ire-2 (37.7% to WMP), which was the most profitable under 2012 prices. This is due to a greater difference in the values of cheese and WMP in these individual years (shown in Table 1).

After incorporating production and lactose costs, the maximum difference in net revenue between New Zealand Scenario NZ-2 and Scenario NZ-6 was US$687 million. This represents the increase in costs associated with cheese production and WP processing; which were greater than the costs to process WMP even when lactose purchase costs are included in the analysis.

When the 2010, 2011 and 2012 prices were separately used in the New Zealand scenario, the lowest net revenue occurred in Scenario NZ-6 in 2010 and 2012, as well as in Scenario NZ-3

Table 9. Costs and net revenue (millions, US$) using 2012 market values for each scenario after accounting for manufacturing costs

Scenario (Ireland)[1]	Processing cost	Lactose cost	Net revenue	Scenario (NZ)[2]	Processing cost	Lactose cost	Net revenue
Scenario Ire-1	382	–9.8	2,168	Scenario NZ-1	1,581	–275.1	9,105
Scenario Ire-2	536	–43.5	3,041	Scenario NZ-2	2,129	–536.0	12,257
Scenario Ire-3	543	–37.6	3,035	Scenario NZ-3	1,955	–	11,892
Scenario Ire-4	550	–27.7	3,025	Scenario NZ-4	2,131	–558.2	12,076
Scenario Ire-5	557	–19.8	3,019	Scenario NZ-5	2,096	–259.2	12,246
Scenario Ire-6	564	–11.9	3,010	Scenario NZ-6	2,363	–85.1	11,586

[1]Scenario Ire-1 is 2012 season milk and product mix; Scenario Ire-2 is 100% of post-quota milk into WMP; Scenario Ire-3 is 75% of post-quota milk into WMP, with 25% into cheese; Scenario Ire-4 is 50% of post-quota milk into both WMP and cheese; Scenario Ire-5 is 25% of post-quota milk into WMP, with 75% into cheese; Scenario Ire-6 is 100% of post-quota milk into cheese.
[2]Scenario NZ-1 is 2012 season milk and estimated product mix; Scenarios NZ-2, NZ-3 and NZ-5 have the same initial product mix as the base, with 2020 estimated milk production; Scenario NZ-2 is 2020 production with 2012 portfolio; Scenario NZ-3 is back-calculated to have no lactose deficit, with excess fat and protein going into butter and casein, respectively; Scenario NZ-4 is 100% of increased milk production into WMP; Scenario NZ-5 is back-calculated to recover 80% of lactose from cheese whey to be incorporated into WMP; Scenario NZ-6 is 80% of total milk production into cheese.

Table 10. Effect of yearly variation on net revenue (millions, US$) of each scenario

Scenario (Ireland)[1]	2012	2011	2010	Scenario (NZ)[2]	2012	2011	2010
Scenario Ire-1	2,168	2,404	2,246	Scenario NZ-1	9,105	9,980	9,015
Scenario Ire-2	3,041	3,359	3,070	Scenario NZ-2	12,095	13,274	11,979
Scenario Ire-3	3,036	3,375	3,081	Scenario NZ-3	11,639	13,035	11,892
Scenario Ire-4	3,025	3,385	3,085	Scenario NZ-4	12,076	13,236	11,823
Scenario Ire-5	3,019	3,401	3,095	Scenario NZ-5	12,286	13,476	12,211
Scenario Ire-6	3,010	3,419	3,101	Scenario NZ-6	11,586	13,614	11,730

All prices are relative to 2012 US$. Values are net revenue, costs were assumed to remain the same across years.
[1]Scenario Ire-1 is 2012 season milk and product mix; Scenario Ire-2 is 100% of post-quota milk into WMP; Scenario Ire-3 is 75% of post-quota milk into WMP, with 25% into cheese; Scenario Ire-4 is 50% of post-quota milk into both WMP and cheese; Scenario Ire-5 is 25% of post-quota milk into WMP, with 75% into cheese; Scenario Ire-6 is 100% of post-quota milk into cheese.
[2]Scenario NZ-1 is 2012 season milk and estimated product mix; Scenarios NZ-2, NZ-3 and NZ-5 have the same initial product mix as the base with 2020 estimated milk production; Scenario NZ-2 is 2020 production with 2012 portfolio; Scenario NZ-3 is back-calculated to have no lactose deficit, with excess fat and protein going into butter and casein, respectively; Scenario NZ-4 is 100% of increased milk production into WMP; Scenario NZ-5 is back-calculated to recover 80% of lactose from cheese whey to be incorporated into WMP; Scenario NZ-6 is 80% of total milk production into cheese.

in 2011. Scenario NZ-5 was the most profitable scenario in 2010 and 2012, with Scenario NZ-6 being most profitable in 2011. The difference between best and worst New Zealand scenarios was US$481, US$579 and US$700 million in 2010, 2011 and 2012, respectively, or 5.2%, 6.3% and 7.7% of 2012 net revenue. However, this study did not investigate the effect of increased product supply/demand balance on product value.

Discussion

Milk production in Ireland is projected to increase by 47% between 2015 and 2020 as a result of the lifting of the European milk quotas (Laepple and Hennessy, 2012). In terms of total world supply, this increase would not be expected to be significant, with total Irish production accounting for only 0.87% of global milk production. New Zealand milk production is expected to continue to increase at historic rates of 4% per annum. The increased production will bring Irish output close to 7.5 billion litres and New Zealand output to 26.2 billion litres.

The scenarios outlined for the Irish industry used a base production situation where the additional post-quota milk was directed towards either WMP or cheese production. This results in a reduction in the proportion of milk used for SMP and butter (decreases of 5% and 8.9%, respectively). While the total quantity of milk partitioned towards these products did not decrease, the amount of butter produced decreased from 141,000 t under Scenario Ire-2 to 129,000 t under Scenario Ire-6. This change in butter production was due to the fact that there is a larger requirement for fat to balance cheese standards than there is for WMP.

WMP under the Irish scenario was closely aligned to the proportions outlined in the model inputs, with WMP making up 34.4% of the product portfolio in Scenario Ire-2 and 8.1%

in Scenario Ire-6. The quantities of milk products in Scenario Ire-1 matched current Irish industry product portfolios. The gross revenue for Ireland is projected to increase significantly between the current and 2020 scenarios irrespective of product portfolio, being worth around US$870 million. However, the difference is around US$37 million between the best and the worst 2020 scenarios (1.46% of 2012 gross revenue), and similarly in net revenue terms, the difference is US$31 million (1.45% of 2012 net revenue). However, this analysis is centred very much on the production of commodity products and does not include depreciation or capital costs to alter available facilities to produce the altered portfolio, such as, e.g., the building of new cheese-processing capabilities. There is scope to add value through development of speciality products for specific markets. This can only be justified if all associated costs (including any capital development costs) are lower than the value of the additional returns.

For future New Zealand scenarios, a series of differing mixes were used, ranging from 80% of all milk processed as cheese to 80% lactose recovery from WP to 100% of future milk allocated to WMP production. This gave a diverse range of possible future scenarios. The availability and usage of imported lactose in the system had one of the largest effects on net returns within this study. When imported lactose was removed from the system in Scenario NZ-3, the increase in milk production was greater than the increase in WMP production (32% versus 8.5%, respectively). This highlights the relatively high proportion of lactose that is currently being purchased by the New Zealand dairy industry. When 80% of all New Zealand milk was processed into cheese, WMP production decreased to 11.5% of total exports, with cheese making up 55.2% of exports.

Between the 2012 and 2020 New Zealand scenarios, gross revenue increased by US$2–3 billion. The differences in gross revenue between top and bottom 2020 scenarios resulted from a difference of 300,000 t of export product. The difference in gross revenue can be attributed to different product mixes and values of the products produced. This indicates that processing decisions in New Zealand scenarios will have significant impacts on farmer income. Obviously, markets will ultimately decide directions and product portfolios. The analysis completed in this study does not take external market considerations into account.

Costs in both systems were greatest in scenarios where cheese was the predominant product produced; this was caused by the combined costs of producing cheese and processing WPs. In the Irish scenarios, an increase of 1% in cheese production as part of total exported products increased costs by US$1.4 million, excluding costs required to build processing capability. In the New Zealand system, this is not easy to calculate due to the diversity of scenarios investigated; however, it can be seen that the Scenario NZ-6 has costs that are US$200 million greater than the next most costly scenario (Scenario NZ-4; predicted 2020 milk production, with increased milk production allocated to WMP).

Yearly variation was greatest between 2011 and 2012 for Irish scenarios, with the 100% cheese scenario experiencing the greatest variation. Under 2011 prices, it was the most profitable, but in 2012, it was the least profitable. In contrast, the variation in New Zealand scenarios was greatest between 2010 and 2011, except for Scenario NZ-6 and Scenario NZ-3, where it was greatest between 2011 and 2012. Similar to New Zealand, Scenario Ire-6 was the second most profitable in 2012 but least in 2010 and 2011. Market values used in the modelling represented a period of smoother pricing, with the previous years (2008–2009) having a sharp decline, with the years after showing a sharp increase (2013–2014) and decrease (2014–2015). The dates selected for price modelling reduced the impact of the large severe variations in market values on the modelled outcomes.

The results of the yearly modelling variations illustrate the complexity of the considerations required for product portfolio development, as a decision made under 2011 prices may negatively affect returns if the future markets are more like those in 2012. This study clearly shows that the addition of flexibility into processing capacity will be the key to ensure that maximum returns can be achieved, given variation in component prices. While additional capacity may have cost implications, it will facilitate significant flexibility within the overall system. Processors could incorporate processing sector–level modelling to identify areas for future processing growth. This would allow individual processors to identify areas for profitable expansion of their processing sector. The frequency of evaluation would depend on the processor; however, annual review would avoid continuation of an unprofitable venture.

Conclusion

For New Zealand, the manufacture of WMP was associated with the highest lactose costs, due to the need to purchase foreign lactose for incorporation into WMP. When the costs associated with the alternative milk-processing capabilities are excluded, net revenue is greatest for Scenario Ire-2 (100% of post-quota milk into WMP production) and greatest in Scenario NZ-2 (2020 production with 2012 portfolio). If cheese value was to increase at a greater rate than WMP value, the results would change in this analysis with cheese-dominant portfolios returning greater net revenue. It is unlikely that either Irish or New Zealand dairy industries will dramatically alter their product portfolios in this short-term time horizon; there will most likely continue to be slight annual modifications as have occurred over the past 20 years. This will allow for optimal usage of existing facilities as well as development of new capacity for altering total portfolio output similar to Scenarios Ire-2-5 as investigated for Ireland.

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