Milk production seasonality post quota removal: Economic implications for Ireland's milk processing sector

Saisonale Milchproduktion nach Abschaffung der Milchquote: Ökonomische Implikationen für Irlands Milchverarbeitungssektor

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Summary

Ireland's dairy industry is characterised by a seasonal milk production at national level which incurs poor capacity utilisation off peak season in processing plants and a reliance on dairy commodities. In the prospect of quota removal, processors seek suitable strategies for maximising the utility of the expanded milk pool. The seasonal strategies examined in this paper necessitated capacity expansion so as to cover supply peaks, resulted in a less profitable product mix and thus appeared less attractive than a smooth supply. Yet, to account for sectoral interdependencies, it is proposed to integrate these findings with an analysis of seasonality in milk production and transport.
Keywords: Milk production seasonality, processor profitability, dairy product mix, producer milk price, linear programming

Zusammenfassung

Irlands Milchwirtschaft ist national durch eine saisonale Produktion geprägt, die abseits der Lieferspitzen mit ungenügender Kapazitätsauslastung in der Verarbeitung und einer Überrepräsentation von Produkten geringer Wertschöpfung einhergeht. Für die erhöhte Milchmenge nach Auslaufen der Quotenregelung ermitteln Verarbeiter geeignete Nutzenmaximierungsstrategien. Die hier untersuchten saisonalen Stra-

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tegien erforderten Kapazitätsaufstockungen infolge von Lieferspitzen, ergaben einen weniger profitablen Produktmix und erschienen für die Verarbeitung somit weniger attraktiv als ein flaches Anlieferungsprofil. Um sektorale Interdependenzen zu berücksichtigen, wird eine Ergänzung um eine Analyse von Produktion und Transport vorgeschlagen.
Schlagworte: Saisonale Milchproduktion, Profitabilität der Milchverarbeitung, Produktmix, Erzeugermilchpreis, Lineare Programmierung

1. Background

Ireland's climate allows for pasture-based milk production which is seasonal at national level and entails various economic impacts on processing (e.g. poor plant utilisation off peak supply, reliance on commodity-type products). In 2011, cow's milk supplies to milk processors amounted to 5.9 m tonnes (94% domestic, 51% of which was produced from April to July; CSO, 2012). In the prospect of quota removal, processors seek strategies for maximising the utility of the projected 50% increase in supplies (DAFM, 2010a) which could focus on maintaining a seasonal or encouraging a flatter supply curve. While continued seasonality would involve substantial investment in national processing capacities, smoothing the profile would incur costs for producers when converting to year-round dairying systems with greater use of imported feed and less focus on pasture utilisation.

Few models analyse economic aspects of seasonality on Ireland's dairy industry (e.g. BREEN, 2001; BUTLER, 2006; QUINLAN et al., 2011). This paper (NoQ study) extends a study by HEINSCHINK et al. (2012, Quota study) which examined economic effects of production seasonality on the processing sector in a quota-constrained environment. The scenarios Q-Baseline (peak-to-trough ratio: 4.9:1), Q-Smooth (PTR: 1.3:1) and Q-Seasonal (PTR: 14.1:1) registered an annual raw milk (RawMilk) pool of 273,746 tonnes each at varying monthly supplies (Fig. 1). It was concluded that, although Q-Smooth achieved the highest processor profitability, strategy choices should consider the implications for producers as opting for year-round dairying involves costs at farm level. The NoQ study's objectives were (a) to estimate the capacity expansion required for processing the extra RawMilk and (b) to examine technical and financial impacts of production seasonality on Ireland's milk processing sector post quota given the capacity expansion identified in step (a).

2. Scenarios

NoQ-Baseline, NoQ-Smooth and NoQ-Seasonal were based on the reference scenarios Q-Baseline, Q-Seasonal and Q-Smooth, respectively, as discussed in HEINSCHINK et al. (2012). The monthly distribution of RawMilk supplies was identical in the Quota- and the NoQ studies (Fig. 1). However, to account for volume increases post quota removal as forecast, total annual intake was raised to 410,619 tonnes with the purpose of investigating the economic implications of a +50% RawMilk pool on the processing industry while the production sector operated

- a spring-calving pattern resulting in an intake profile representative for Ireland (3-year average, 2008-2010; CSO, 2012) (**NoQ-Baseline**);
- an even calving pattern (**NoQ-Smooth**);
- a more compact spring-calving pattern (TEAGASC, 2009) targeting feed cost reduction at producer level (**NoQ-Seasonal**).

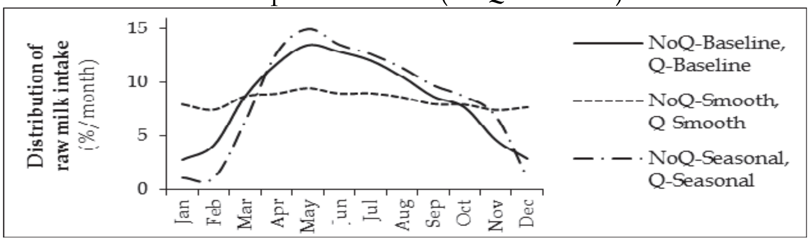

Fig. 1: Distribution of raw milk intake – Quota- and NoQ scenarios
Source: Own illustration, 2012

3. Model

The milk processor model as described in HEINSCHINK et al. (2012) was constructed as a single-criterion optimisation problem which, by means of the objective function (F.1), identified the maximum processor gross surplus, a corresponding optimum product mix (tonnes/month) and the marginal values (MV) of the milk solids (index *s*) fat (FAT), protein (PRO) and lactose (LAC) at monthly intervals (index *t*). PRO was further divided into casein protein (PROC) and whey protein (PROW).

(F.1) Max. $Surplus = SalesRev - (TotalVC + TotalFC)$

where *Surplus* = annual processor gross surplus (€); *SalesRev* = sales revenue (€); *TotalVC* = total processor variable costs (VC) (€); *TotalFC* = total processor fixed costs (FC) (€). *TotalVC* were broken down into VC of RawMilk collection and handling (*CollHandVC*) as well as product processing, storage and labour (i.e. all costs related to temporary workforce). *TotalFC* comprised general overheads (e.g. depreciation, IT, managerial salaries), stock FC (i.e. opportunity costs of capital tied up in stocks), labour FC (i.e. costs of permanent workforce) and investment FC. The objective function was subject to a set of technical constraints addressing milk solids levels in RawMilk and products, input and output maxima and labour provided by permanent workforce. The MV allowed for deriving the marginal producer milk price (F.2).

(F.2) $MPMP_t = \Sigma_s (SolidsMV_{st} \times \mathrm{SolidsI}_{st} \times 100) - VolDeduct_t$

(F.2a) $VolDeduct_t = (CollHandVC + TotalFC) / \Sigma_t \, Input_t$

where *MPMP* = marginal producer milk price (€c/kg RawMilk); *SolidsMV* = milk solids MV (€/kg solid); SolidsI = milk solids (%/kg RawMilk). The *MPMP* consisted of a reward for FAT, PRO and LAC and a volume deduction (*VolDeduct*; €c/kg RawMilk) which was computed by spreading *CollHandVC* and *TotalFC* over the RawMilk pool (F.2a).

The seasonality costs reflect the financial disadvantage of a seasonally operated plant over one with a smoother intake curve; these costs were calculated as the difference (Δ) between key financial results of the situations compared (F.3, F.3a). In the present paper, NoQ-Smooth represented the reference case for both NoQ-Baseline and NoQ-Seasonal.

(F.3) $TotalSeasonC = \Delta\, Surplus$

(F.3a) $SeasonMixC = TotalSeasonC - \Delta\, (TotalVC + TotalFC)$

where *TotalSeasonC* = total seasonality costs (€); *SeasonMixC* = product mix costs (i.e. *Surplus* foregone due to a less profitable product mix; €).

4. Data

The data, retrieved from publicly accessible sources or made available by dairy co-operative production managers and management accountants, was identical in all NoQ scenarios unless specifically declared.

Input: The annual RawMilk pool of 410,619 tonnes contained approx. 3.7% FAT, 3.3% PRO (of which 82% PROC, 18% PROW) and 4.6% LAC. Due to differing intake profiles and tanker capacity utilisation, the annual weighted average *CollHandUVC* (€/tonne RawMilk; UVC = unit

VC) amounted to € 9.18 in NoQ-Baseline, to €8.33 in NoQ-Smooth and to € 9.45 in NoQ-Seasonal (adapted from QUINLAN et al., 2011).

Output: Milk solids levels were specified for the product lines liquid milk (LiqMilk), butter, cheddar cheese (Cheddar), casein, whole milk powder (WMP), skim milk powder (SMP), whey powder (WheyP) and lactose (Lactose). Product prices and UVC incurred by processing, storage and labour (Table 1) were invariant throughout the year so as to carve out more clearly the economic effects of milk supply shifts. An annual interest rate of 5% (Industry consultation) was applied for calculating opportunity costs of capital tied up in output on stock.

Tab. 1: Product prices, unit variable costs (UVC), capacities and composition

Product line[a]	**Product price[b]** (€/tonne /month)	**Processing UVC[c]** (€/tonne /month)	**Storage UVC[c]** (€/tonne /month)	**Labour UVC[c]** (€/tonne /month)	**Capacities pre expan.[d]** (tonnes /month)	**Product composition: FAT/PRO/LAC[a,e]** (kg solids/ tonne output)
LiqMilk	627	200	0.00	24	2,831	35/33/46
Butter	2,620	258	8.13	12	1,050	800/4/3
Cheddar	2,759	306	5.80	36	1,875	320/PROC: 260/1.9
Casein	6,480	241	5.80	154	357	9/PROC: 900/1.9
WMP	2,471	265	3.14	71	Dry, 298	280/250/380
SMP	1,973	217	3.14	71	Dry	8/330/545
WheyP	535	216	3.14	71	Dry, ByP	13/PROW: 122/780
Lactose	577	250	3.14	71	n/a, ByP	0/2/946

[a] Product lines: Liquid milk (LiqMilk), whole milk powder (WMP), skim milk powder (SMP), whey powder (WheyP); Milk solids types: Fat (FAT), protein (PRO), lactose (LAC), casein protein (PROC), whey protein (PROW).

[b] LiqMilk: Derived from YOUNG (2009), NMA (2010) and CSO (2012); All other product lines: Average prices Jan 2008 to Dec 2010, derived from PRODUCTSCHAP ZUIVEL (2010) – Butter, Cheddar, SMP: Prices for Ireland; Casein, Lactose: Prices for the USA; WMP, WheyP: Prices for the Netherlands.

[c] BREEN (2001), adjusted for inflation and productivity increases (CSO, 2012; EC, 2010; IPCC reports; processor annual reports), validated (Industry consultation).

[d] Capacities prior to expansion; Processing capacities: Butter, Cheddar, Casein, derived from IDB (2010) and DAFM (2010b); Market capacities: LiqMilk, WMP; Dryer capacities (Dry): WMP, SMP, WheyP; no capacity maximum applicable (n/a): Lactose; ByP = by-product.

[e] LiqMilk: BREEN (2001); Butter, Cheddar, Casein, WMP, SMP: IDB (Personal communication, 2010); WheyP, Lactose: FSA (2002).

Source: Own compilation based on data from multiple sources, 2012

Plant infrastructure in place: Maximum monthly RawMilk capacity was limited to 41,300 tonnes (derived from CSO, 2012, DAFM, 2010b).

Maximum output volume was constrained by processing or market capacities (Table 1). Prior to investment, maximum monthly dryer output was 2,250 tonnes (derived from IDB, 2010; DAFM, 2010b). It was assumed that unrestricted storage was available in commercial storage facilities. General overheads were € 3.99 m (Industry consultation).

Plant investment: Various RawMilk, Butter and Dryer investment options with 15 years of useful life and the corresponding acquisition costs were indicated (Industry consultation). An annual interest rate of 5% (Industry consultation) was applied for estimating financing costs.

Labour: The average monthly labour requirement as identified for NoQ-Smooth determined the labour pool available from permanent workforce (15,840 hours/month) for all NoQ scenarios. Unlimited availability was assumed for temporary labour. Labour costs were €21 per hour for both permanent and seasonal workforce (CSO, 2012).

5. Results

Technical and financial key results are presented in the following.

Plant investment: NoQ-Smooth did not require any plant investment for accommodating the +50% RawMilk. Contrarily, both seasonal NoQ cases involved the expansion of RawMilk, Butter and Dryer capacities whereas NoQ-Seasonal effectuated a notably larger investment (€64m) as compared to NoQ-Baseline (€ 45 m). Spreading these acquisition costs over 15 years of useful life (depreciation and financing), NoQ-Seasonal registered € 7.5 m, NoQ-Baseline recorded € 5.3 m in year 1 (Table 2).

Capacity utilisation and optimum product mix: LiqMilk capacity was fully exploited in all scenarios contrary to the average annual capacity utilisation of manufactured outputs which improved with a lower degree of intake seasonality. NoQ-Smooth registered the highest annual Casein (4,284 tonnes) and Cheddar (21,510 tonnes) output and thus the highest yields of the by-products WheyP and Lactose. The product mix reported for NoQ-Baseline and NoQ-Seasonal was similar whereas a higher degree of intake seasonality prompted the model to allocate a larger proportion of RawMilk to milk powders (WMP, SMP). This was most obvious in NoQ-Seasonal which registered the highest milk powder yield (11,540 tonnes). Yet, average dryer utilisation was poorest in NoQ-Seasonal (41%) (Table 3) as (a) other outputs were more profitable so their capacities were exploited first (peak month: LiqMilk, Cheddar, Casein, WMP: 100%; Butter: 92%) and (b) extra dryer capacity was created for processing any remaining RawMilk at supply peaks into milk powders. It should be noted that dryer capacity lay idle for most of the year and utilisation fell even below 2% from December to February as opposed to peak utilisation of 82%. Similarly, LiqMilk, Cheddar, Casein and WMP capacities were fully exploited (100%) unlike Butter capacity (65%) in NoQ-Smooth's peak month; however, dryer capacity was much better utilised (77%, annual average).

Tab. 2: Output capacity maxima post expansion and investment fixed costs

	NoQ-Baseline		NoQ-Smooth		NoQ-Seasonal	
Capacity max. post expan. (tonnes/month)	Total	of which expan.	Total	of which expan.	Total	of which expan.
RawMilk max. capacity	55,400	(14,400)	41,000	(0)	61,500	(20,500)
Butter max. capacity	1,442	(392)	1,050	(0)	1,703	(653)
Dryer max. capacity	4,083	(1,833)	2,250	(0)	5,000	(2,750)
Investment fixed costs (€'000)	Total	Year 1	Total	Year 1	Total	Year 1
All investment projects	45,132	5,265	0	0	64,010	7,469
of which RawMilk expan.[a]	(17,700)	(2,065)	(0)	(0)	(25,300)	(2,952)
of which Butter expan.	(3,807)	(444)	(0)	(0)	(4,960)	(579)
of which Dryer expan.	(23,625)	(2,756)	(0)	(0)	(33,750)	(3,938)

[a] Assuming greenfield construction where all facilities need to be put in place.

Source: Own calculations 2012; adapted from industry consultation

Tab. 3: Optimum annual product mix and average annual capacity utilisation

	NoQ-Baseline		NoQ-Smooth		NoQ-Seasonal	
	Output (tonnes)	*Cap.util.*[a] (%)	*Output* (tonnes)	*Cap.util.*[a] (%)	*Output* (tonnes)	*Cap.util.*[a] (%)
LiqMilk	33,972	100.0	33,972	100.0	33,972	100.0
Butter	9,777	56.5	7,841	62.2	9,529	46.6
Cheddar	15,413	68.5	21,510	95.6	15,678	69.7
Casein	4,117	96.1	4,284	100.0	3,360	78.4
WMP	3,396	Mark[b]: 63.3	3,131	Mark[b]: 58.4	3,413	Mark[b]: 63.6
		Dry: 6.9		Dry: 11.6		Dry: 5.7
SMP	6,101	Dry: 12.5	505	Dry: 1.9	8,127	Dry: 13.5
WheyP	13,878	Dry: 28.3	17,000	Dry: 63.0	12,776	Dry: 21.3
Lactose	2,210	n/a	2,709	n/a	2,039	n/a
Dryer	23,374	47.7	20,637	76.5	24,316	40.5

[a] Capacity utilisation based on capacities post expansion; Processing cap.: Butter, Cheddar, Casein, derived from IDB (2010) and DAFM (2010b); Market cap. (Mark): LiqMilk, WMP; Dryer cap. (Dry): WMP, SMP, WheyP (derived from industry consultation); no cap. maximum applicable (n/a): Lactose.

[b] Mark increased in line with RawMilk pool by 50% to 5,364 tonnes/year.

Source: Own calculations, 2012; using the model by HEINSCHINK et al., 2012

Surplus and MPMP: It was apparent from NoQ-Smooth that a lower degree of intake seasonality resulted in a higher *Surplus* (+8.6% relative to NoQ-Baseline, +13.2% relative to NoQ-Seasonal) which is mostly explained by a higher sales revenue and considerably lower FC, particularly due to the absence of investment FC in NoQ-Smooth. Simultaneously, NoQ-Smooth registered the highest marginal RawMilk costs payable to the milk suppliers (€101.3m; RawMilk pool × *MPMP* × 1000) which is based on the logic that, if capacities of the more profitable products (LiqMilk, Casein, Cheddar) are not fully utilised, the processor can afford to offer a higher payment to milk producers; once RawMilk can only be allocated to the manufacture of less profitable outputs, the *MPMP* declines as it would be irrational for the processor to maintain a higher level of compensation at a lower expected sales margin. The *MPMP* is not necessarily equal to the actual producer milk price *(APMP)* since the latter depends on the bargaining power of the negotiating parties. The *MPMP* could serve the purpose of a reference value in pricing negotiations as (a) paying producers an *APMP* higher than the *MPMP* will result in a *Surplus* below and (b) paying a lower *APMP* will result in a *Surplus* above the maximum identified (Table 4).

Tab. 4: Financial statement

	NoQ-Baseline	**NoQ-Smooth**	**NoQ-Seasonal**	**NoQ-Baseline**	**NoQ-Smooth**	**NoQ-Seasonal**
	Annual totals (€'000)			Per unit (€c/kg RawMilk)		
Sales revenue	145,214	148,310	143,743	35.36	36.12	35.01
Variable costs, total	–25,528	–25,364	–25,903	–6.23	–6.18	–6.31
of which *CollHandVC*	(3,770)	(3,465)	(3,881)	(0.92)	(0.84)	(0.95)
of which *ProcessingVC*	(20,799)	(21,721)	(20,798)	(5.07)	(5.29)	(5.06)
of which *StorageVC*	(392)	(64)	(492)	(0.10)	(0.02)	(0.12)
of which *LabourVC*	(567)	(114)	(732)	(0.14)	(0.03)	(0.18)
Fixed costs, total	–13,970	–8,119	–16,361	–3.40	–1.97	–3.98
of which *StockFC*	(725)	(139)	(913)	(0.18)	(0.03)	(0.22)
of which *LabourFC*	(3,992)	(3,992)	(3,992)	(0.97)	(0.97)	(0.97)
of which *OverheadsFC*	(3,988)	(3,988)	(3,988)	(0.97)	(0.97)	(0.97)
of which *InvestmentFC*	(5,265)	(0)	(7,468)	(1.28)	(0.00)	(1.82)
Processor gross surplus	105,716	114,827	101,479	25.73	27.97	24.72
Marginal RawMilk costs	–91,337	–101,264	–87,381	–22.24	–24.66	–21.28
Imputed profit	14,379	13,563	14,098	3.49	3.31	3.44

Source: Own calculations, 2012; using the model by HEINSCHINK et al., 2012

Seasonality costs: Total seasonality costs amounted to € 9.1 m in NoQ-Baseline and to € 13.4 m in NoQ-Seasonal relative to NoQ-Smooth.

Approx. one third of these costs (NoQ-Baseline: 34.0%, NoQ-Seasonal: 34.2%) originated from a less profitable product mix (Table 5).

Tab. 5: Seasonality costs – NoQ-Baseline, NoQ-Seasonal relative to NoQ-Smooth

	NoQ-Baseline	**NoQ-Seasonal**	**NoQ-Baseline**	**NoQ-Seasonal**
	Annual totals (€'000)		Per unit (€c/kg RawMilk)	
Seasonality costs, total[a]	9,111	13,348	2.22	3.25
of which Product mix	3,096	4,567	0.75	1.11

[a] Difference between *Surplus* of the scenario with a more seasonal intake curve (NoQ-Baseline, NoQ-Seasonal) relative to the reference scenario (NoQ-Smooth).

Source: Own calculations, 2012

6. Discussion and conclusions

Results of the NoQ study were in line with those of the previous study by HEINSCHINK et al. (2012), however, the impact of production seasonality was more pronounced in the NoQ situations: From the processor's viewpoint, (a) a lower degree of intake seasonality entailed a higher *Surplus*, better capacity utilisation, a higher *MPMP*; (b) *TotalSeasonC* correlated positively with a higher degree of intake seasonality. By switching from a seasonal supply curve as prevalent in the quota-constrained market (Q-Baseline) to a flat curve post quota (NoQ-Smooth), processors could handle the +50% RawMilk pool without investment in extra capacities and better utilise capacities in place. While an evenly distributed profile appears beneficial for the processor, it would however raise farm-level costs in particular due to a larger dependency on more costly concentrates and investment in housing, both of which are characteristics of year-round dairying. Thus, it is proposed to integrate the milk processor model with a milk producer model (e.g. BUTLER, 2006) and a milk transport model (e.g. QUINLAN et al., 2011) so as to draw a comprehensive picture of milk production seasonality post milk quota. An integrated model would allow for assessing more accurately the technical and financial implications (e.g. investment) of production seasonality as well as interlinkages between these segments. From an economic viewpoint, inferences on strategies aiming at the reduction of seasonality are meaningful only if the new strategy's benefits surmount the costs incurred by switching to this approach for all agents involved.

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