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THE IMPACT OF SLOW STEAMING ON REFRIGERATED EXPORTS FROM NEW ZEALAND

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ABSTRACT

The practice of slow steaming has had a significant impact on New Zealand export industries with increased transit times in some cases causing significant reductions in shelf life once the product has reached the retail stage. The longer transit times also impose the extra cost to exporters of having more inventory tied up in transit. While there is clear evidence to suggest slow steaming has reduced fuel consumption and hence fuel emissions and fuel costs, these savings have not been passed on by the liners to their customers. However, there is no indication that slow-steaming has caused a significant reduction in export earnings for New Zealand (at least up to the middle of 2014). A predicted move to super-slow steaming would put extra strain on the New Zealand meat industry especially, with their lucrative European chilled lamb market under particular threat.

1. INTRODUCTION

Food exports are vital to New Zealand's economy, with the food sector currently accounting for more than half of the Nation's gross domestic product (GDP). A significant fraction of New Zealand's food exports, are transported chilled or frozen (61 % in 2007 according to Fitzgerald et al., 2011a). Some are transported literally to the other side of the World. In fact it has been argued that it was refrigerated transportation that made it viable for New Zealand to become a country in its own right instead of being part of Australia (Copland, 1972; King, 2003). However, the recent practice by shipping lines of reducing the speed at which ships cruise on the open sea ('slow steaming') poses threats to some of New Zealand's export markets, particularly chilled products travelling to Europe. The aim of this paper is to assess the impact to-date of slow-steaming on New Zealand's exports, weighed against the claimed environmental benefits, and the likely impact if proposed further reduction in steaming speeds is implemented.

2. SLOW STEAMING

In 2009 shipping companies lost an estimated US$22 billion, as reported by the Los Angeles Times (White, 2010). The loss was attributed to the global economic downturn that resulted in an over-capacity of shipping which, coupled with rising costs of fuel oil, led to the practice of what has come to be known as 'slow steaming' (Guan et al., 2014). Whereas ships had been cruising at between 23 and 25 knots prior to 2009, this speed has been reduced to below 20 knots (Carriou, 2011; MIA, 2012). For New Zealand companies exporting refrigerated food to Europe, this has had a significant impact on the shelf-life once the food has arrived at its destination retailer. For example, the New Zealand Meat Industry Association estimated that a reduction from 24 knots steaming to 18 knots steaming meant that the effective shelf-life was reduced by about a week (MIA, 2012). Yet, according to the CEO of Maersk Line, the practice of slow steaming is here to stay, regardless of any recovery of the global economy: "*For Maersk Line slow steaming is here to stay because it remains a win-win-win situation. It is better for our customers, better for the environment, and better for our business*" (Maersk, 2010). However, many New Zealand exporters (i.e. some of the 'customers' being referred to) are not convinced that they have in fact won, since they were never consulted about the change (van Elswijk, 2011; Spanjaard and Warburton, 2012) and the shipping lines do not necessarily pass savings on to their customers, who are penalised by having more inventory tied up in transit (Spanjaard and Warburton, 2012; Kloch, 2013; Htut, 2014). Additionally, a reduction in cruising speed does not necessarily translate to reduced emissions, since ship engines are designed for optimal operation at a set cruising speed (Woo and Moon, 2014), and it has been questioned whether environmental benefits are sustainable (Cariou, 2011; van Elswijk 2011).

3. ASSESSING THE IMPACT TO-DATE OF SLOW STEAMING

3.1 Shelf life of refrigerated products

The first successful export of refrigerated meat from New Zealand was sent to England by sail in 1882, taking 14 weeks (King, 2003). Today, food exports comprise more than half of New Zealand's export earnings. The major food categories being exported are dairy, meat, seafood and horticultural products, with each sector relying heavily on refrigerated transport. Different food products require different transportation temperatures and have differing shelf lives (Heap, 2010). Generally the food will be stored at as low a temperature as possible while avoiding significant damage to the product, since shelf-life is strongly dependent on temperature. This temperature can range from above 10 °C (e.g. for bananas) to well below 0 °C (e.g. frozen beef). Many fruit and vegetables, as well as chilled meat products are transported at temperatures marginally above their initial freezing temperatures (i.e. in the region of -2 °C to 0 °C). The shelf lives for chilled products range from less than two weeks to 6 months or more, while the shelf-lives of frozen products can be well over a year. The six major food products that are exported chilled from New Zealand are butter, cheese, lamb, beef, kiwifruit and apples. Of these, lamb and beef have the shortest shelf-life, of 9 to 10 weeks. Figure 1 shows the breakdown of the time chilled lamb spends during the different phases between production in New Zealand and consumption in Europe.

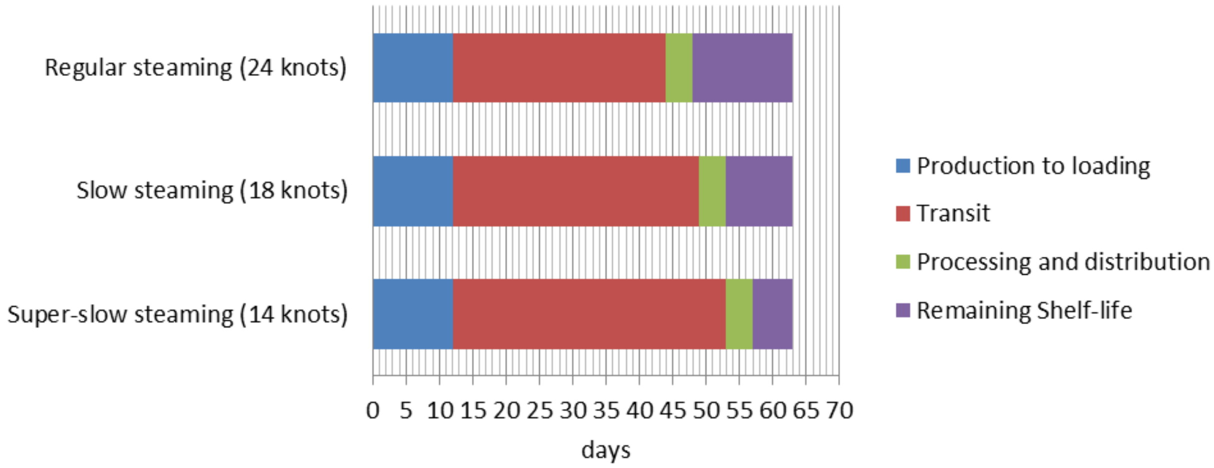

Figure 1: Chilled lamb time breakdown, form processing to consumption (adapted from MIA, 2012)

At 24 knots transit time from New Zealand to Europe is 32 days, whereas at 18 knots it is 37 days and at 14 knots it is 41 days. Figure 1 shows that any increase in transit times is removed from the remaining shelf-life once the product has reached the retailer, since the time between processing and loading onto a ship and unloading and redistribution for retail are set. A residual in-market shelf-life of less than 2 weeks is likely to result in significant loss of product due to spoilage and/or reluctance of retailers to take the risk stocking such products. Clearly the practice of slow steaming places extra strain on New Zealand's export revenue with increased risk of chilled product arriving in Europe in an unsaleable condition. The quality impact of slow steaming on frozen products is likely to be minimal due to the normally much longer shelf-lives

3.2 Environmental impact

According to Maloni et al. (2013) total ocean shipping produces 3% of the global GHG emission (which is about the same as the emissions produced by Germany), and Jolly et al. (2000) stated that approximately 31% of the world's food supply requires refrigerated transport. Maritime transport moves 99.5% (by mass) of New Zealand's international traded products (Fitzgerald et al., 2011a). Global in-port emissions as a result of manoeuvring, loading/unloading etc. are approximately 6% of total emission, but due to the relative isolation of New Zealand that number is closer to 1 %, which means the potential for reduction in emissions due to slow steaming is greater for New Zealand shipping than for other trade routes. Offsetting this is the fact that for refrigerated transport 19 % of the fuel is used for refrigeration rather than steaming (Fitzgerald et al. 2011b), and therefore the percentage reduction in fuel consumption as a result of slow steaming will be smaller for refrigerated shipping than for shipping without refrigeration. Chilled product transportation is inherently less energy efficient in terms of refrigeration usage than frozen products since efficiency is sacrificed in order to achieve the tighter control required to maximise shelf-life while maintaining the chilled state.

The power required to overcome fluid drag is proportional to the cube of the velocity of the object passing through the fluid (Cengel and Cimbala, 2010). Hence, in principle, a reduction of steaming speed from 24 knots to 18 knots should more than halve the steaming power required ($[18/24]^3$ = 42%), and hence also more than halve the quantity of exhaust emissions. In reality the analysis is not quite as simple due to the fact that the efficiency at which ship engines operate is itself dependent on velocity, but it is still useful as a rule of thumb. For ships carrying 1000 TEU or more driven by standard two-stroke diesel engines, Carriou (2011) stated that provided the slow-steaming speed is within 10 % of the design speed the ship engine efficiency will not change significantly; however, once the speed reduction becomes greater than 10 % of design speed the specific fuel-oil consumption factor increases (i.e. the engines of the ship operate less efficiently). Table 1 shows estimates of the fraction of vessels utilising slow-steaming and the reduction in fuel consumption of ships from slow steaming for a range of ship size bands. Table 1 shows estimates of the reduction in fuel consumption of ships from slow steaming as a function of ship size:

Table 1: Effect of slow-steaming on fuel savings of container ships (adapted from Carriou, 2011)

Vessel size TEU	Proportion of Vessels slow steaming %	Reduction in average annual fuel consumption between 2008 and 2010 %
1000-2000	19.4	2.6
2000-3000	22.6	4.8
3000-5000	37.2	7.7
5000-8000	65.7	14.0
8000+	75.5	17.0

Table 1 shows the effect of ship on size energy savings, which illustrates the rationale behind shipping lines move to larger, slower ships (Spanjaard and Warburton, 2013). Carriou (2011) estimated that in the period 2008 to 2010 the total CO_2 emissions from international shipping decreased from 170 million tonnes per annum to 115 million tonnes, a reduction of approximately 11 %; however, for the Australasia/Oceania services the CO_2 emissions reduction was only 4 %, since relatively few ships had implemented slow-steaming on these routes at that stage (Table 2). Tai and Lin (2013) also concluded that slow-steaming had resulted in a definite reduction in NO_x, SO_2, CO_2, and hydrocarbon emissions.

Table 2: Comparison of environmental impacts of slow steaming between Oceania/Australasian routes and worldwide (adapted from Carriou, 2011)

	Number of vessels	Slow Steaming %	Mean size (TEU)	Reduction in shipping CO_2 emissions from 2008 to 2010 %
Australasia/Oceania	96	27.1	3490	4.1
Worldwide	2051	42.9	4485	11.2

While it appears that there clear reduction in CO_2 emissions, it is not clear whether this reduced environmental impact is sustainable. Carriou argued that for each ship in a given shipping route there was a critical fuel-oil cost, below which the financial incentive for slow-steaming would be insignificant and companies might return to pre-2008 speeds. He suggested that fuel levies might need to be imposed on some routes (including the Australasia/Oceania routes) in order for slow-steaming practices and associated environmental benefits to be sustained. A similar conclusion was drawn by Yin et al. (2014) who developed a cost model to determine the optimal steaming speed as a function of the cost of fuel oil, the cost of carbon taxation and the cost of container transit time. Woo and Moon (2014) also argued that a levy system would be required in order for slow-steaming practices to be sustained when the price of fuel oil is relatively low. So while the CEO of Maersk seems to be adamant that slow-steaming is here to stay (Maersk, 2011), not everyone is equally convinced if the decision is left solely to the shipping lines.

3.3 Economic impact on New Zealand

Figure 2 shows export data obtained from the New Zealand Government's official statistics bureau (Statistics New Zealand). Note that the meat and offal, seafood, and fruits, vegetable and nuts categories shown in Fig.2 were for products that were 'chilled, frozen, dried or otherwise simply preserved' while dairy products were simply categorised as 'processed dairy products', but include chilled and frozen products (e.g. butter and cheese).

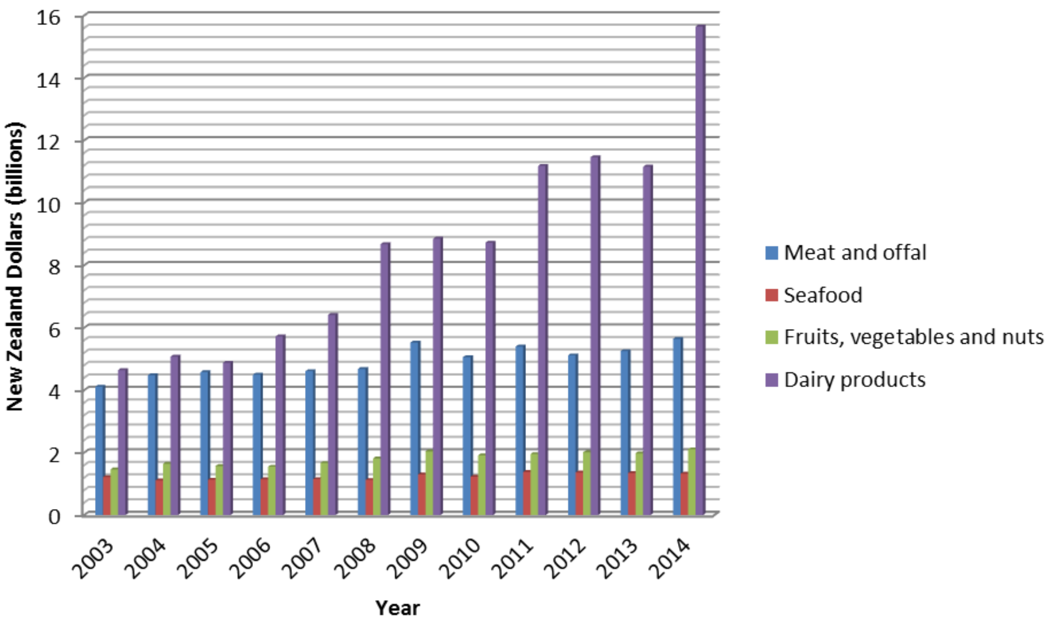

Figure 2: New Zealand exports of major food categories by year in billions of New Zealand dollars (source: Statistics New Zealand)

Figure 2 does not reveal any discernible change in trends around the period 2008 to 2010 (the time when slow-steaming practices were implemented by shipping companies). The most salient observation from Fig. 2 is the growth in dairy products export values compared to relatively static figures of the other three categories. A key driver in this trend has been the conversion from farming sheep and beef-cattle to more profitable dairy stock. This is made evident by the increasing number of dairy cattle and the decreasing number of beef cattle and sheep (Anon., 2012).

Since Fig. 2 does not separate refrigerated food from non-refrigerated food, it is worth examining the data more closely. Figure 3 shows the volume of chilled lamb and chilled beef exports, which are the meat products most sensitive to transportation time, over the last ten years (MIA, 2014). Again there is no clear change around the period 2008 to 2010 that would suggest chilled meat exports have been directly impacted by slow-steaming.

Figure 4 shows the percentage of the total export value of sheep-meat (both chilled and frozen) to different export regions. A clear trend can be seen after 2010 where the value of exports to North Asia begins to increase sharply, the value of exports to the European Union (EU) decreases markedly, while the rest of the world remains essentially steady. The single most significant driver of this trend is the increase in volume of chilled lamb going to China (MIA, 2014); however, the market price for chilled lamb in Europe is still significantly higher than in China. With the total volume of chilled lamb exported not showing a significant, continued upward trend (Fig. 3), it can be concluded that some of the export volume that has in the past been sent to the EU is now being sent to North Asia, although it is difficult to say for certainty whether slow steaming has been a contributing cause of this trend.

Figure 5 shows export earnings for chilled horticultural productss; again there is no clear impact from the introduction of slow steaming about the years 2008 to 2010. The major horticultural exports are less vulnerable to the implications of slow steaming than lamb and beef since they have longer shelf lives and the majority of the product is not destined for European markets (NZ Horticulture, 2013). Likewise dairy exports have not been affected significantly by slow steaming, according to the logistics officer of the major dairy exporter in New Zealand (Weir, 2011).

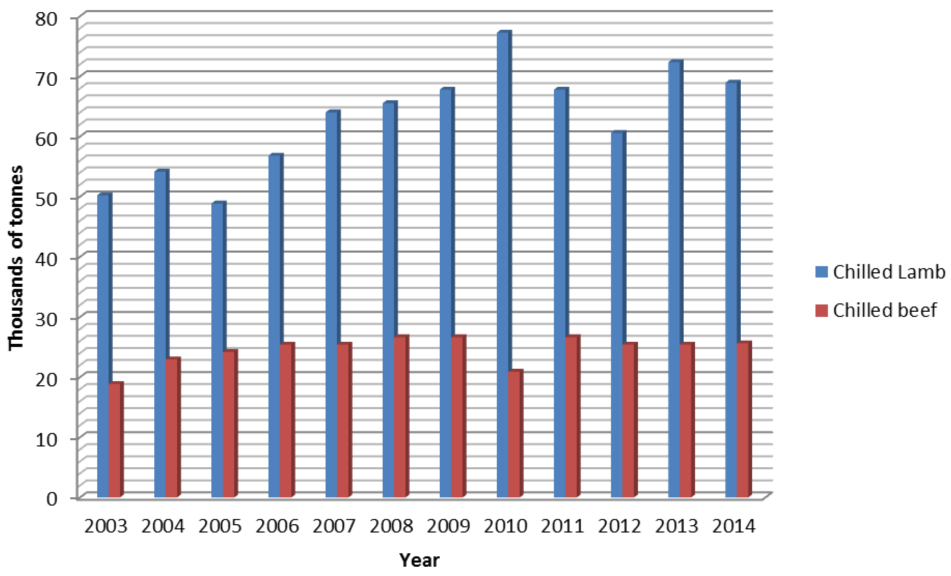

Figure 3: New Zealand chilled lamb and chilled beef export volumes (adapted from MIA, 2014)

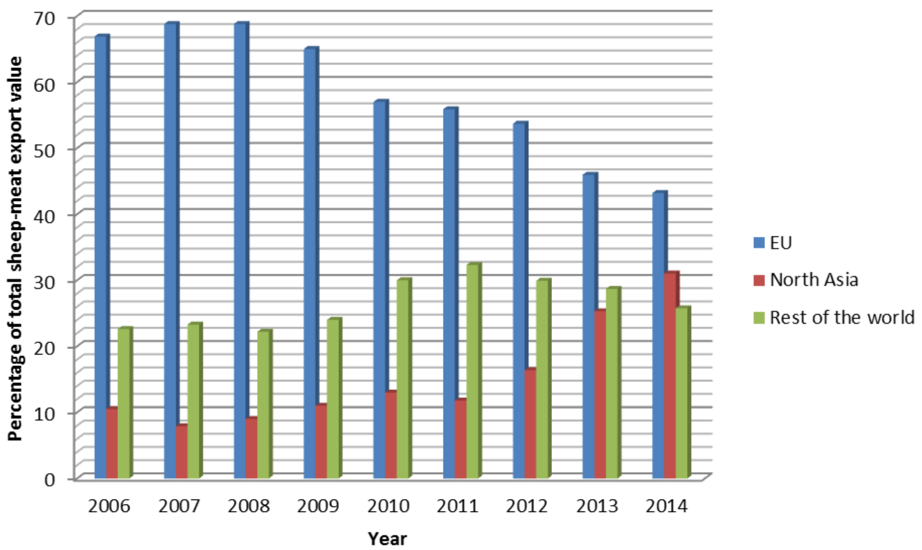

Figure 4: New Zealand sheep-meat export values by region (MIA, 2006-2014)

So the export data does not show any clear indication that the effect of slow-steaming has had a definite economic impact on New Zealand to-date; however, the meat industry in particular has reported new challenges in maintaining its European chilled product markets as a result of slow steaming, and it continues to be a matter of concern (Spanjaard and Warburton, 2012; MIA 2014). Amongst other effects, slow steaming has imposed extra costs on all exporters because of the larger volume of inventory they are required to keep, (van Elswijk, 2011; Weir, 2011; Htut,2014; MIA, 2014).

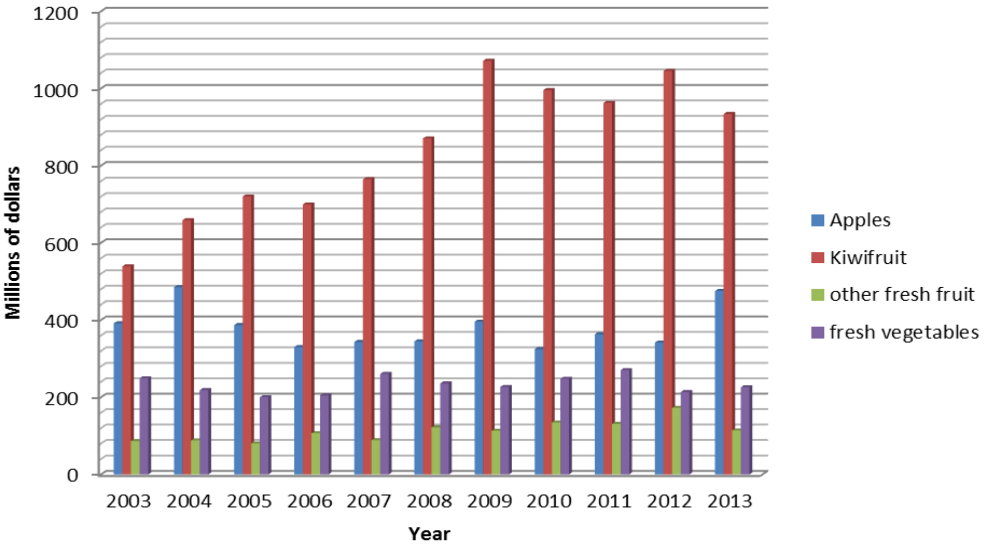

Figure 5: New Zealand exports of chilled horticultural products by value (data from: www.freshfacts.co.nz)

4. THE LIKELY IMPACT OF A MOVE TO SUPER-SLOW STEAMING

So it appears that the reduction from an average speed of 24 knots to 18 knots has not caused a major impact on New Zealand's exports while achieving a claimed reduction in CO_2 emissions of 4% (Table 2). But what about a further reduction, as has been suggested (Spanjaard and Warburton, 2012; MIA, 2014; Woo and Moon, 2014), to speeds as low as 14 knots ('super-slow steaming)? Of New Zealand's major exporters, the red meat industry seems to be most at risk. According to the Meat Industry Association: "*Any further expansion of slow steaming will restrict the industry's ability to grow the chilled trade, and if super slow steaming were to be introduced, would potentially put the current chilled trade at risk*" (MIA, 2014). After slaughter a series of biochemical reactions occur in the animals muscle tissue which convert it to meat (Devine and Chrystall, 2000). This process is relatively slow and is sensitive to temperature and the pH of the muscle, along with other factors. In fact the relatively lengthy time (several weeks) in transit allows the chilled meat to age well, which enhances its quality. With the super-slow steaming rate of 14 knots, there may only be five days or less for the meat to be purchased and eaten as chilled product (Figure 1). Such a short shelf-life remaining may deter European retailers from continuing to stock the chilled product due to the relatively high risk of spoilage prior to sale. With very little control over the shipping logistics (Spanjaard and Warburton, 2012) New Zealand meat exporters in particular are faced with the very real threat of losing a lucrative market. So what can be done to maintain the European chilled lamb market?

4.1 Shelf-life extension through improvement of current practices

New Zealand meat exporters have recently put greater efforts into improving their hygiene during processing and transportation and also tightening control of temperature in order to achieve shelf-life extension (Ritchie, 2014). The increase in initial shelf-life could offset the effect of slow steaming on shelf-life.

4.2 Re-direction of chilled products to other markets

The trend shown in Fig. 4 suggests that the demand for chilled lamb in North Asia will continue to grow, and it seems probable that the transfer of market volume from Europe to North Asia may continue. The disadvantage of this option is that the product currently sells for a significantly lower price (NZ$5.04/kg compared to NZ$7.46/kg in Europe), meaning that the total export value would be greatly reduced if the total volume exported remained steady. Nevertheless, this option has been considered as a contingency by some in the industry. One of the reasons for the higher price received in Europe is that it receives essentially table-ready, higher-value cuts, whereas the lamb sent to China has tended to be lower value and typically undergoes further processing; however, the demand for higher-value cuts in China is increasing (MIA, 2012). With successful marketing to increase the up-take if high-value lamb, the shrinkage or complete loss of a European market may conceivably be entirely compensated for by the growth in the North Asian market.

4.3 Development of a European super-chilled lamb market

In order to eke out a few extra days of shelf-life, exporters are holding their product as close as possible to the initial freezing point of the lamb (ref), trialling the effects of incremental decreases of 0.1 °C the storage temperature. But what happens when the extra shelf-life requires storage temperatures below the initial freezing point of lamb (–1.0 °C to –1.5 °C; Rahman, 2009)? One option would be to move to a 'super-chilled' product in which the product is cooled at a rate such that individual ice crystal size is limited and total ice content is less than 30 % of the total water within the product (Kaale et al., 2013). Provided the process is implemented correctly, the product will appear to be unfrozen, i.e. ice crystal formation will not be visible and the product will not be rigid. The process requires very tight control as small changes in temperature can cause significant changes to the ice content and super-chilling technology is in its infancy. In addition, the consumer would need to be educated about the meaning of 'super-chilled product' in order for it to be priced above frozen product and, preferably, close to chilled product. However, in principle super-chilled product could, perhaps, provide a solution for maintaining New Zealand's premium European lamb market

5. CONCLUSIONS

Of New Zealand's major chilled food exporters the meat industry has been affected most significantly by slow steaming, with significant reduction in remaining shelf-life of chilled products once they have arrived in Europe. All exporters of refrigerated products have been affected by the cost of having extra inventory tied up in transit. Slow steaming appears to have reduced fuel consumption and hence fuel emissions and fuel costs but these savings do not appear to have been passed on by the shipping lines to their customers. Slow-steaming does not appear to have caused a significant reduction in export earnings for New Zealand (at least up to the middle of 2014). A predicted move to super-slow steaming would put extra strain on the New Zealand meat industry especially, with their lucrative European chilled lamb market under particular threat. This threat may be counteracted by improving processes and procedures to increase shelf-life, diverting product to other markets and possibly introducing a super-chilled lamb product.

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