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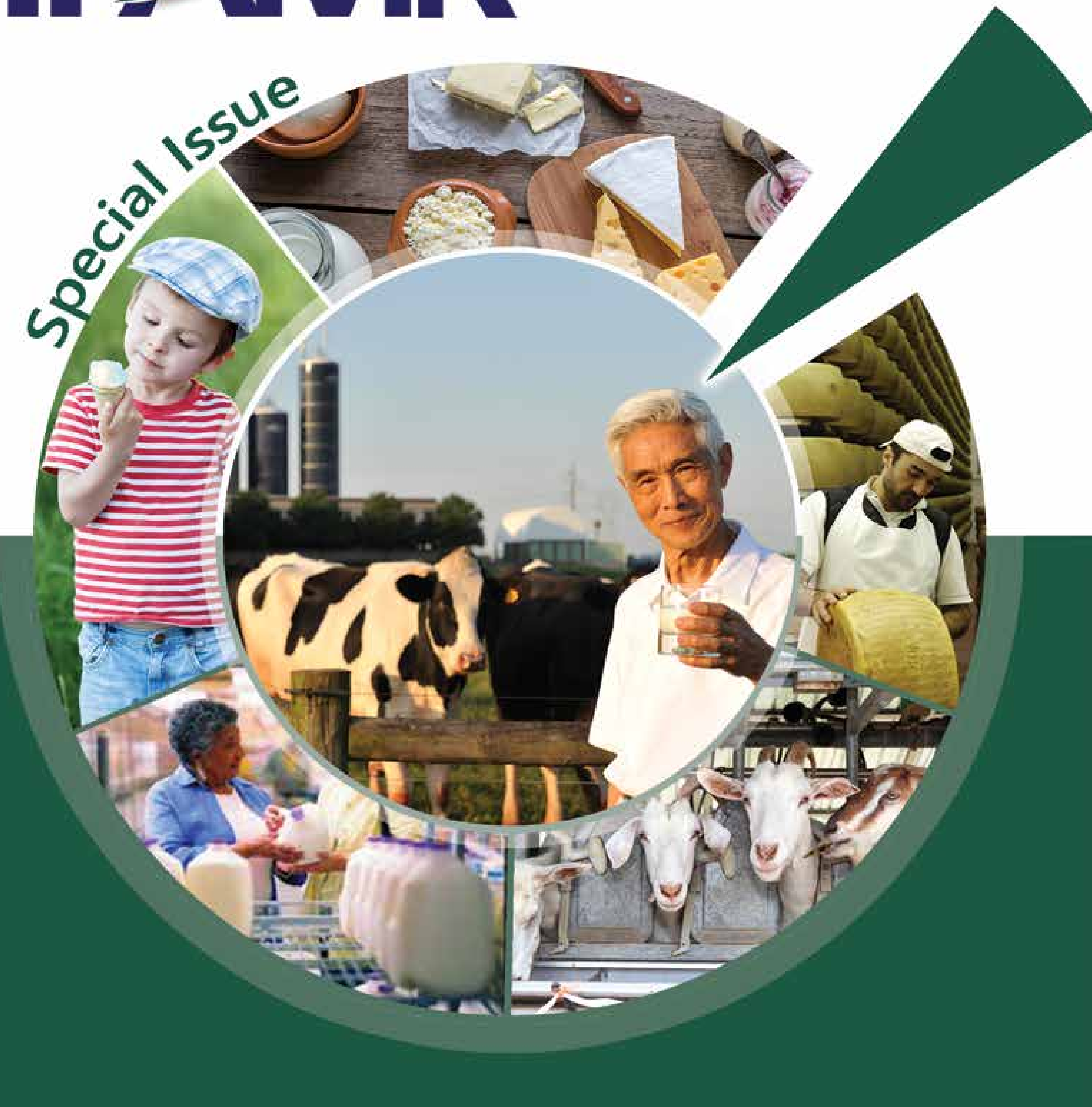

Assessing the Status of the Global Dairy Trade

The International Food and Agribusiness Management Review
Volume 19 Special Issue B

Assessing the Status of the Global Dairy Trade

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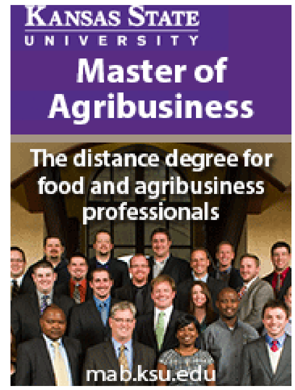

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EDITOR'S NOTE

Dear Colleagues,

The International Food and Agribusiness Management Review is pleased to publish the latest edition of the *IFAMR Special Issue Series*—eight since 2008. The editorial team from the USDA–Economic Research Service (ERS) has brought together a fantastic cohort of dairy expertise from academia and industry from around the world. Their task was to make sense of the dramatic changes of the last ten years in the global dairy industry. *Assessing the Status of the Global Dairy Trade* comprises fourteen articles and reviews the various drivers affecting the world's dairy complex. The Issue will serve as a key reference document for the industry going forward. Don't hesitate to reach out with questions and comments to editors: Christopher G. Davis, William Hahn, Brian W. Gould, Donald Blayney, John Newton and Ekaterina Vorotnikova. The IFAMR is delighted to serve a valuable role by giving voice to editorial teams; advancing critical issues facing agribusiness; and providing an accessible platform through its open access and web-based format. Enjoy the issue.

Peter Goldsmith, Executive Editor, IFAMR

International Food and Agribusiness Management Review
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Assessing the Status of the Global Dairy Trade

EDITOR'S INTRODUCTION

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Growth in Dairy Trade

Over the last decade, interest in global dairy trade has intensified—partially because of the enormous impact that domestic and international policies have had or are projected to have on the global trade and domestic supply. One significant example in the negotiations is the proposal made by the World Trade Organization (WTO) during the Nairobi ministerial in December 2015 in effort to help stabilize world dairy prices by eliminating export subsidies over the next four years (WTO 2016).

Global dairy consumption has been on the rise steadily since 2005, with the exception of 2009 and 2015[1]. Dairy imports grew in value from $15 billion in 2005[2] to $43.2 billion in 2014[3], a 187% increase in US dollars. Similarly, global dairy exports expanded 175% in value from 2005 to 2014. The leading dairy importers from 2005 to 2009 were the United States, Mexico, Japan, Russia, and the European Union-28 (EU–28). From 2010 to 2015, the situation changed as China

[1] The main reason dairy trade fell in 2009 was due to the global financial crisis. In 2015, dairy trade dropped for several reasons. Those reasons include a weaker demand for dairy commodities; Russia's ban on dairy imports from several countries; and the elimination of Europe milk supply quotas (Cessna et al. *Forthcoming*). The export subsidies received by European Union's dairy farmers from their government also contributed to lower international dairy prices and a weaker demand for dairy commodities. The increase in Europe's dairy production grew faster than consumption.
[2] The import and export values calculated for 2005 exclude values from Iran, Belarus, Bolivia, and Kenya which were not reported or unavailable in World Trade Atlas®.
[3] The import and export values calculated for 2014 exclude values from Azerbaijan and Jordan which were not reported or unavailable in World Trade Atlas®.

emerged as the world's largest dairy importer followed by Russia, the US, Mexico, and Japan (World Trade Atlas®). Although the demographic landscapes of dairy consumption are changing globally, the major suppliers of dairy commodities have remained relatively unchanged from 2005 to 2015. New Zealand is the world's largest dairy exporter in terms of volume. The four top global dairy exporters during the observed period based on value are the EU–28, New Zealand, the US, and Australia.

While many dairy commodities are traded internationally, some of the largest global exchanges involve cheese, nonfat dry milk (including skim dry milk), whey, and butter. In 2015, these four commodities accounted for 50% of the total value of global dairy imports (World Trade Atlas®). Of all the dairy commodities imported globally in 2015, cheese accounted for 24% of the total value. The global cheese import had increased 43% from 2010 to 2014 (World Trade Atlas®). The largest importers of cheese (in value) in 2015 were Russia, the US, and Japan.

Nonfat dry milk (NFDM) was the second largest (in value) dairy commodity imported, making up 11% of the world's total dairy imports in 2015. The import value of NFDM grew by 96% from 2010 to 2014 and the top importers in 2015 included Mexico, China, Indonesia, and Malaysia (World Trade Atlas®). Whey and butter were the third and fourth largest dairy commodities imported, respectively. Both whey and butter balanced out at 7% of the total value of dairy imported in 2015. Over the five-year span from 2010 to 2014, the value of global imports of whey and butter increased by 81% and 62%, respectively (World Trade Atlas®). The world's leading importers of whey are China, the US, and Indonesia, while Russia, Iran, and China are the leading importers of butter.

Free Trade Agreements

Of the many factors influencing agricultural commodity trade, bilateral and regional agreements have been among the most important. The number of bilateral and regional trade agreements rose more than 80 percent from 2008 to 2014. Of the over 350 regional trade agreements (RTAs) in force and reported to the World Trade Organization, more than 70% have been concluded since 2000 (OECD 2015). Bilateral and regional trade agreements are important to the competitiveness of food and agricultural industries. Even though free trade agreements (FTAs) focus primarily on tariff elimination, sensitive agriculture sectors, such as dairy, may be excluded from the terms of agreements (NAFTA 1994). A rich body of literature discusses the impacts of bilateral and multilateral trade agreements (Beckman et al. 2015; Burfisher et al. 2014; European Commission 2014; Fontagne et al. 2014; Arita et al. 2014; Davis et al. 2014; Davis et al. 2013). Several studies have shown that regional trade agreements in agriculture have a direct effect on trade and that the elimination of tariffs through trade agreements can substantially increase trade among nations (Vollrath and Hallahan 2011; Burfisher et al. 2014; OECD 2015).

The two trade agreements presently under negotiation that are expected to have a significant impact on the dairy trade are the Trans-Pacific Partnership (TPP) and the *Transatlantic Trade and Investment Partnership* (T-TIP). On October 5, 2015, the President of the United States and leaders of other countries concluded negotiations on TPP, which is yet to be ratified by the US Congress (USTR NEWS 2015). The TPP is a trade and investment agreement negotiated by twelve Pacific Rim countries, including the United States and eleven other countries: Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam (Burfisher et al. 2014). T-TIP is designed to eliminate trade barriers and reduce the restrictions on investment that traditionally have been in place during trade transactions between the United States and the EU–28. Both the TTP and the TTIP are important trade agreements and are sure to increase the competitiveness of dairy trade given that the proposed country members are some of the world's largest exporters and importers of dairy commodities.

Impediments to Trade

Many factors continue to hinder trade flows. Trade impediments may include *sanitary and phytosanitary (SPS) measures*[4], import policies such as tariffs, embargos, quotas, import licensing, customs practices, labeling, and various types of certification. In 2015, Russia imposed a ban on dairy imports from the EU–28, Australia, Canada and Norway. During the same period, the EU–28 eliminated their milk supply quotas, which caused milk production to rise and reduce prices. Russia's ban on dairy imports and the EU elimination of milk production quotas were partially responsible for the global dairy imports drop of 27% from 2014 to 2015.

In Turkey, US dairy exports were suspended due to the continuation of negotiations on a new bilateral veterinary certificate for dairy commodities. US dairy exports to Turkey were suspended on April 1, 2016. Turkey's imports from the US recently dropped from 4,931 metric tons (MT) in 2014 to 99 MT in 2015 (FAS TR6016). Another example is Pakistan who has proposed a rise in import tariff on milk powder. If approved, the increase may benefit Pakistani farmers but will impede imports from the world's four largest dairy suppliers, New Zealand, Australia, the EU–28, and the U.S (FAS PK1610).

Trends in Domestic Dairy Production

Global milk production has been strong over the last several years leading to expanded growth in trade in most years with a sudden drop off in 2015. For example, from 2005 to 2013, the world milk production increased more than 16% (FAO 2005–2013). An average of 594.4 million metric tons of cow milk was produced throughout the world over the observed nine year period. The six major milk suppliers, the EU–28, the US, India, China, Russia, and Brazil, accounted for more than 80% of the world's cow milk production during the last four years (FAS–USDA). The EU–28 was by-far the largest milk producer, providing an average of 30% of the world's cow milk during the previous four years (FAS–USDA). Although the EU–28 is the world's largest milk producer, the greatest growth in milk production among the top six milk suppliers occurred in India and China.

According to USDA–FAS, India's cow milk production grew 15.3% from 2012 to 2015, while China production expanded by 15.1% (FAS–USDA). Factors contributing to India's growing production include the world's largest dairy herd[5] (water buffalo, indigenous, and cross-bred cattle), improved veterinary services, feed and farmer education, artificial insemination, the growth and success of cooperatives particularly Gujarat Cooperative Milk Marketing Federation,

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[4] SPS measures include standards necessary to protect human, animal, plant life, or health from risks arising from the entry or spread of plant or animal-borne pests or diseases, or from additives, contaminants, toxins, or disease-causing organisms in foods, beverages, or feedstuffs (Womach 2005).

[5] Food and Agriculture Organization (FAO). FAOSTAT database: http://faostat3.fao.org/home/E

Food and Agriculture Organization (FAO). Domestic Animal Diversity Information System. http://dad.fao.org/

and increases in consumer demand and GDP (FAO; Jones et al. *Forthcoming*). China's production growth was motivated by relatively low production costs stemming from the recruitment of small-scale farmers who utilized abundant feed resources and slack labor (Fuller et al. 2006; Gale and Hu 2009).

The increase in Brazil milk production almost mirrors that of India and China. From 2012 to 2015, Brazil milk production grew by 14.3% (FAS-USDA). One reason for Brazil's success is the governmental support milk producers receive by participating in state government dairy development programs designed to increase productivity through pasture improvement and animal genetics (FAS BR0917). Brazil's increase in milk production is also partially motivated through exemption from state government value-added taxes on the sale of milk by producers and cooperatives.

Over the last four years, the other major milk-producing areas experienced moderate growth ranging from 7.6% for the EU–28, to 4.9%, and 4% for China, and the United States, respectively. According to USDA, the milk production forecast for 2016 has lowered as the pace of cow herd expansion has slowed. However, the production forecast for 2017 is raised as higher forecast milk prices and lower feed costs in late 2016 and early 2017 are expected to lead to higher 2017 cow numbers (WASDE 555).

Among the five other major milk-producing areas, Russia's milk production fell over the past four years, partially due to the unsettled payments of subsidies under state support programs. Global dairy production is expected to continue to increase in the near future as world GDP rises and consumers' preferences for different types of dairy products expand.

Challenges in Domestic Dairy Supply Policies

Domestic policies have been one of the driving forces behind milk production surpluses and the promotion of trade opportunities for some major and minor dairy commodity exporters. Dairy supply policies are used for different reasons in countries across the globe. Some countries use them to help their dairy industries produce sufficient amounts of dairy commodities to satisfy the demands of their citizens. Governments may also establish dairy supply policies to control milk production to help increase domestic dairy prices and farm income. In April 2015, the European Union eliminated its milk quota system after more than thirty years. The discontinuation of this milk supply policy is expected to generate a large milk surplus and expand dairy export potentials for the producers there, which could potentially have detrimental impacts on the US and/or other major dairy exporters.

Canada's dairy sector has operated under a supply management system since the early 1970's. As one of the minor milk producers and dairy exporters, Canada could face challenges as its national subsidized dairy program create issues for UF–85 (ultra-filtered milk with 85% protein) imports from the US (FAS–CA16028). According to Foreign Agricultural Service, "The Canadian Milk Supply Management Committee has authorized the expansion of the dairy ingredients that can be sold at world prices for use in cheese production, and other products, in the national Class 4m Permit Program". This authorization could affect the US UF–85 trade to Canada which is currently treated by processors as an eligible ultra-filtered milk used in manufacturing cheese.

Summary of Dairy Special Issue Articles

Growth in Dairy Trade

*Matthew Salois— Global Dairy Trade Situation and Outlook***—** looks at the recent world trade situation with a special emphasis on conditions that have led to increased imports in Asian markets. Dairy prices, production, consumption, and trade have been volatile in the past few years due to a number of factors including feed-cost volatility and policy shifts. The recent expansion of milk production has resulted in lower prices and profits for dairy producers. Salois predicts that supply increases will be moderate in the near term, producing somewhat higher dairy prices and a slower expansion of dairy production.

*Peter Vitaliano –Global Dairy Trade: Where Are We, How Did We Get Here and Where Are We Going?***—**also examines US dairy export growth, focusing on specific factors that led to it. He notes that increases in US dairy production since 2002 have largely led to increases in exports with a small increase in domestic consumption. He identifies global income growth—especially in lower-income countries—as the key factor in increasing overall world dairy trade. Trade policy changes, the Uruguay Round Agreement and NAFTA, are also important in the expansion of US dairy exports. Vitaliano also outlines reasons for higher world dairy prices that have been observed in recent years. (Supply expansion and lower feed costs have reduced US and world prices in the past three years.) Forecasts of dairy market conditions in the United States and the European Union are provided as well.

The previous two articles show that the most important markets for U.S dairy exports are across the Pacific Ocean. This currently provides West Coast dairy producers an advantage in serving the largest export markets. The planned expansion of the Panama Canal should decrease the export costs for the rest of the United States. Canal expansion would also allow Australia and New Zealand to better serve European and West-African markets. In *The Effects of Panama Canal Expansion on US Dairy Trade Flows: West, East, and Gulf District Regions—Vorotnikova and Devadoss* built a model to predict how the pattern of world dairy trade might change in response to lower-cost shipping through the Panama Canal. They find major impacts on the world dairy trade, particularly lower shipping costs leading to an elimination of US butter exports to Africa; and Oceania is able to squeeze US butter out of African markets.

The United States, Oceania, and the European Union are the world's largest dairy product exporting regions. In *Price Transmission in Global Dairy Markets***—***John Newton* examines dairy-product prices in these three regions using vector auto-correction and vector error-correction models. US prices for non-fat dry milk and cheddar cheese are affected by the prices in the other two markets. Shocks in the US non-fat dry milk market are not transmitted to the other two regions; US cheddar cheese price shocks affect Oceania cheddar prices.

Free Trade Agreements

Christopher Davis—Potential Impacts of Trans-Pacific Partnership on Japanese Cheese Imports notes that Japan is the world's second largest cheese importer and is negotiating for membership in the Trans-Pacific Partnership (TPP). The United States, Australia, and New Zealand are important suppliers of cheese to Japan and are also involved in the TPP negotiations. The TPP could reduce Japanese cheese tariffs. Davis estimated a model of Japanese cheese demand to determine how Japan's cheese imports would change with no tariffs. The model treats cheese from each source as a differentiated product. He finds that the Australian cheese imports are less sensitive to price changes due to changes in Japan's import rules than those from the United States and New Zealand. The US and New Zealand cheese exports are, therefore, likely to show larger increases due to the TPP than those from Australia.

Like Davis, *Asci et al.* in *Implications of Trans-Pacific Partnership for the US Dairy Industry* look at the potential impacts of the TPP on dairy trade. The research differs from Davis's in that the Asci looks at dairy trade in the Pacific region in general, not only cheese trade in Japan. Most of his analysis focuses on supply and demand shifts for aggregate dairy imports and exports. *Asci et al.* also forecast changes in bilateral trade in milk powder. Reducing tariffs increase demand and supplies throughout the world. For the most part, the supply and demand shifts are modest—less than 1%. Changes in trade between countries shows larger percentage changes.

Impediments to Trade

Many of the articles in this special issue have noted the recent importance of China as an importer of dairy products [Salois, Vitaliano, and Gale & Jewison] and that changes in Chinese policy are a factor in the recent declines in Chinese dairy imports. *Tao et al.* in *Estimating Restrictiveness of SPS Measures for China's Dairy Imports*—looks at the evolution of China's dairy safety regulations and measures the effect these policies have on China's dairy imports. To a large extent, these dairy-safety regulations were driven by domestic incidents. *Tao et al.* measures these regulations' effects on China's major import suppliers. Their estimates show that these regulations impose higher costs than China's tariffs. They also note that supplying safer dairy products can be an effective competitive strategy for China's suppliers.

Pemberton et al.—The Effects of Trade Liberalization on Dairy Trade and Domestic Milk Production in CARICOM—analyze the effects of trade policy reforms for the Caribbean nations Jamaica, Trinidad & Tobago, and Barbados. Domestic milk producers in these countries have a number of serious problems leading to lower domestic production and higher imports. The most important suppliers of dairy products to these three countries are New Zealand and the European Union. Dairy imports in all three countries are subject to a number of policies that were reformed as a result of the Uruguay Round negotiations. Pemberton et al. estimate general factors that drive imports and domestic dairy demand and measure how much the three country's dairy trade has responded to import liberalization.

Trends in Domestic Dairy Production

The Western United States, especially California, is an important dairy production and exporting region, especially for the Asian/Pacific markets. *Matthews et al*. in *The Role of California and Western US Dairy and Forage Crop Industries in Asian Dairy Markets* study the linkages between dairy and forage production in California and the rest of the west in order to measure the competitiveness of Western US exports and the ability of Western US production to expand to meet increasing Asian/Pacific demand. The authors indicate that limits to Asian forage production will restrict Asia's ability to meet its projected dairy demand with domestic milk. This offers an opportunity to Western US producers to serve Asian markets.

Spanish dairy farms have faced challenges in recent years due to lower milk prices and changes in European Union policy. Some producers have responded to these challenges by diversifying their operations. *Alvarez et al.* in *Diversification in Spanish Dairy Farms: Key Drivers of Performance* conduct in-depth surveys with a group of diversified dairy producers discovering the major factors that lead to better financial performance.

Gale and Jewison in *China as Dairy Importer: Rising Milk Prices and Production Costs* examine cost of production data for China's milk producers in order to explain the increases in Chinese prices observed in 2006–2014. High Chinese milk prices in this period were an important factor driving China's milk imports. The authors found that about half of the milk-price increase can be attributed to feed cost changes. There appear to be improvements in Chinese dairy labor productivity, small gains in milk per cow, but no change in the productivity of cattle feed. They agree with the previously-cited Mathews study that problems with the supply of grains and forage are likely to constrain the future growth of Chinese milk production.

Challenges in Domestic Dairy Supply Policies

Like the works by Salois and Vitaliano in this issue, *Blayney et al.* note the growth of US dairy exports since the signing of the Uruguay Round agreement. In *Dairy Export Markets: Changing the Structure of US Dairy Demand*— their statistical analysis finds that US dairy exports were significantly different after the Uruguay Round commitments were implemented. The authors note that the United States has focused its export efforts on dry products: whey, non-fat, and whole milk. They believe that there may be opportunities to expand US exports in other products—notably butter. Russian bans on US dairy, weaker Chinese demands, and expansions of world production have contributed to lower US exports in 2014 through 2015.

Nehring et al. in *United States and European Union Dairy Farms: Where Is the Competitive Edge?*—compare cost of production estimates for the United States and seven European Union countries. The cost of production data for all eight countries is detailed enough to allow one to compare costs by farm size. In all countries, the larger farms tend to have lower costs. The authors note that recent policy changes in the European Union could allow a more rapid shift to larger farms, making the European Union dairy farmers relatively more competitive with US producers.

Shadbolt and Apparao in *Factors Influencing the Dairy Trade from New Zealand*—note that New Zealand is the most export-dependent dairy producer in the world. They examine the global and local conditions that drive New Zealand's dairy exports and highlight domestic challenges to dairy production expansion in the country.

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A special thanks to our co-editors: Brian W. Gould, Donald Blayney, John Newton and Ekaterina Vorotnikova for their contributions in helping to bring this issue into fruition and our invited contributors Peter Vitaliano from the National Milk Producers Federation; and Nicola Shadbolt and Dhananjay Apparao of Massey University, New Zealand. The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

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Global Dairy Trade Situation and Outlook

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Abstract

This paper provides an overview of the economic trends and outlook for global dairy trade. Particular attention is given to the Asian market due to the significant role it plays in the global dairy trade. The global dairy market is in a challenging period, particularly given the uneven and volatile market movements. Despite these challenges there is reason for optimism in the international dairy market. There are signs the market is in correction mode as low milk prices are translating into slower production growth which in turn is expected to improve the supply situation.

Keywords: dairy, trade, China, India

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Introduction

Trade in the global dairy market is in a challenging period. Internationally, three key economic factors are driving both uneven and volatile market movements: (1) the Russian extension of the trade embargo until supposedly late 2016; (2) the reduction of import demand from China; and (3) dynamics in the international currency exchange market especially the relative strength of the US dollar. These three key factors set the stage for the global dairy market and will continue to be a challenging trade environment throughout 2016. Significant declines in imports from China and Russia have created a surplus in supply, leading to significant downward pressure on global prices. While the price impact has been uneven across dairy products, the general effect has led to reduced export volumes and lower prices for some US dairy products. Additionally, the strong US dollar has put United States dairy exports at a competitive disadvantage compared to other exporters, especially the EU and New Zealand.

Despite these challenges there is reason for optimism in the international dairy market. There are signs the market is in correction mode as low milk prices are translating into slower production growth which in turn is expected to improve the supply situation. The question then becomes one of timing on the turnaround for prices. World market prices have likely bottomed out or are very near to bottoming out, with some industry analysts suggesting that prices may have perhaps gone too low given the current market fundamentals (Informa 2015). International prices have moved higher in the most recent Global Dairy Trade (GDT) auctions in late 2015, although early 2016 saw a slight reversal back to declining prices (Figure 1)[1].

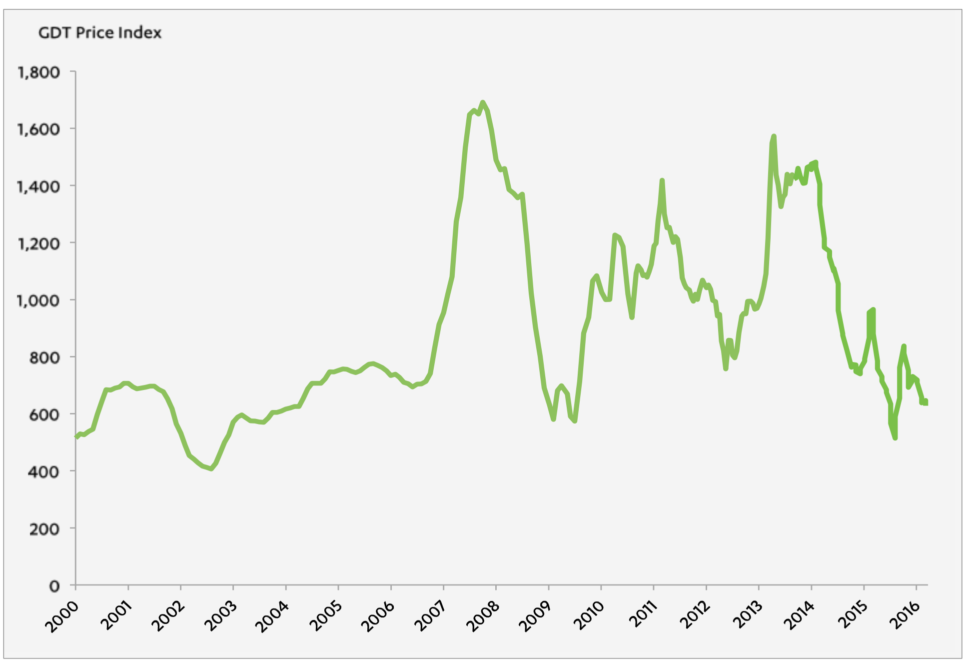

Figure 1. GDT Price Index, five-year view
Source. www.globaldairytrade.info

[1] Global Dairy Trade (GDT) provides market-based benchmark prices for over 30 dairy products globally (www.globaldairytrade.com)

Price response in the GDT is heavily influenced by trading volumes and China engaged in heavy import volumes of milk powder from New Zealand in late 2015 into early 2016. This resulted in the rise in GDT prices in early 2016. The positive price growth quickly returned back to price declines, however, as Chinese imports did not continue and global production levels have not fallen to the degree needed to support price growth. Much of the future direction of the global dairy market is dependent upon the degree of market correction that occurs over the course of 2016.

The international dairy market is increasingly affected not only by the global macroeconomic situation, but especially by economic conditions in Asia (McCully 2015). The region is already an important milk-producing region. As consumption rises in Asia alongside population growth and expansion of the middle class, coupled with increasingly liberalized trade arrangements, Asia is also becoming relevant to the global trade market. While China is clearly one of the largest importers of dairy products, other key Asian importers include Japan, Indonesia, Malaysia, and the Philippines. In addition to import growth, key countries in Asia, like China and India, represent some of the largest global producers of dairy products. Moreover, many of the world's fastest growing dairy companies are based in Asia or serve Asian customers. This trend will no doubt continue in the future, which will have repercussions to the US dairy industry and global dairy trade.

This paper provides an overview of the global dairy market. A particular emphasis is given to the trends and the outlook for the global dairy trade. Dairy is an international market and global economic forces shape not only the world dairy market but increasingly domestic dairy markets as well given the important role that trade plays in the dairy industry. While most of the world's commodities have been "internationalized" for quite some time, the evolution of the dairy industry as a global trade market is a more recent one. The next section of this paper reviews the global dairy trade situation and outlook. The third section takes a deeper dive exploring key trends in the Asian region due to the significant role it plays in the global dairy market. A particular emphasis is given to the key commercial players that have emerged. The final section summarizes and concludes.

Economic Situation and Outlook

Although the global and US dairy outlook remains bearish in the near term, being stuck in a position of oversupply, low prices and stagnant global import demand, international prices are expected to remain low and not recover before 2017.

For perspective, the current situation primarily stems from increased global milk production in 2014 that led to an oversupply of milk in exporting countries in 2015. Key contributing factors to the current situation include lower import demand from China, as well as, the Russian ban on dairy imports from several key producing countries that was extended beyond original expectations.

The Russian ban, which was originally enacted in August 2014, included a ban on most dairy products from the EU, United States, Australia, and Norway in retaliation for economic sanctions imposed on Russia over their involvement in the Ukraine crisis of 2014. Originally, the ban was expected to last about year but has been extended until late 2016. While the ban had little direct effect on the US since no exports were being sent to Russia from the United States, there has been significant indirect effects as Russia was the EU's largest export market. This resulted in a huge displacement of dairy products globally.

Regarding China, dairy imports (especially powder) grew significantly through 2013 into 2014. The huge import levels not only took substantial product off the trade market but also helped to support strong prices. However, Chinese import demand curtailed sharply in the second half of 2014 as they built up substantial inventories. While there have been a few large spikes in import demand from China since then, they remain brief and appear to take advantage of cheap prices rather than forming a stable trend.

Beyond the import issues with China and Russia, the strengthening of the US dollar and a weakening of international currencies has dampened import demand, at least from a US point of view. Going forward, while relatively flat global production is needed for the market to correct itself, milk supply from the EU continues to grow. The outlook for 2017 depends critically on China coming back to the market, global production declining, and potential adverse weather events that further tighten supply.

Figure 2 shows milk production trends for the major exporting countries which include the EU-28, New Zealand, the United States, Argentina, and Australia (USDEC). While the seasonality of dairy production is apparent, the large aforementioned increase in supply that occurred in 2014 over the previous year is also clear.

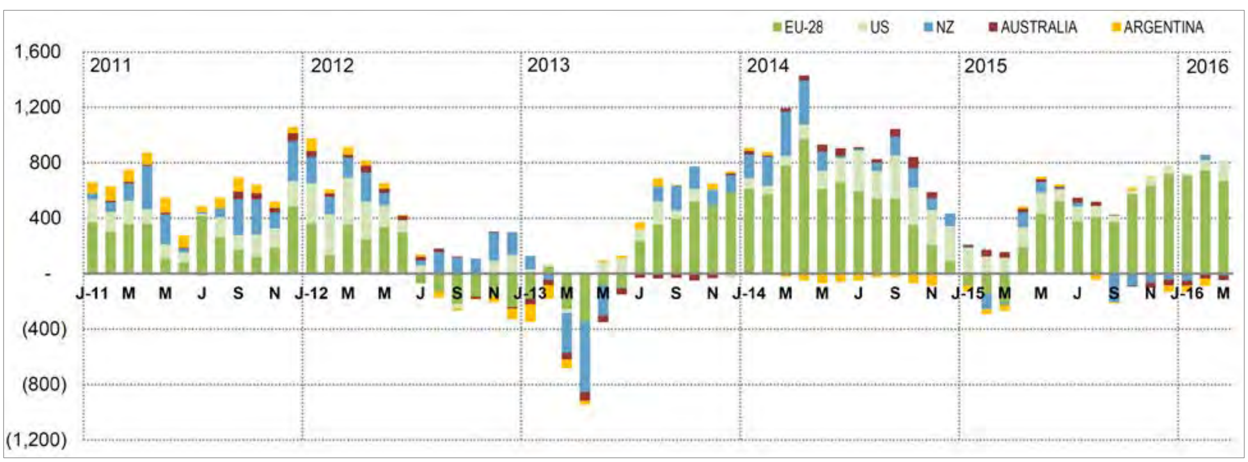

Figure 2. World milk production change from prior year (Key exporters, 1000 MT)
Source. US Dairy Export Council (www.usdec.org)

Moreover, although supply has remained stable throughout 2015/16, the decline in production growth has so far not been enough to offset the declines in import demand. This is evident by the observed trends in global milk prices (Figure 3). Notably, international prices have been on a declining trend since early/mid 2014 (USDEC). Even though the US has experienced downward pressure on dairy prices, the trend has been more mild compared to the price declines experienced by exporters in the EU or Oceania (New Zealand and Australia) especially regarding butter, WMP, and cheese.

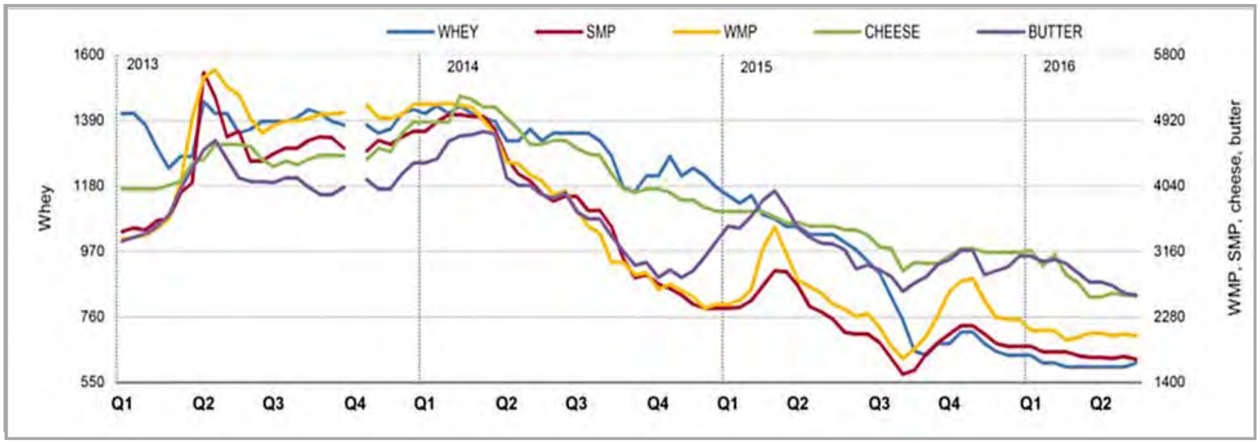

Figure 3. Estimated dairy prices ($/MT)
Source. Global Dairy Outlook, May 2016 (USDEC)

Part of this contrast between the US and world dairy prices has been a very strong domestic demand for butter (and to a lesser extent cheese) which has kept US prices higher than the rest of the exporting world. In fact, the high US butter price relative (Figure 4) to the world market has resulted in the US moving from a net exporter to a net importer of butter in a short amount of time, depicted in Figure 5 (USDA-FAS).

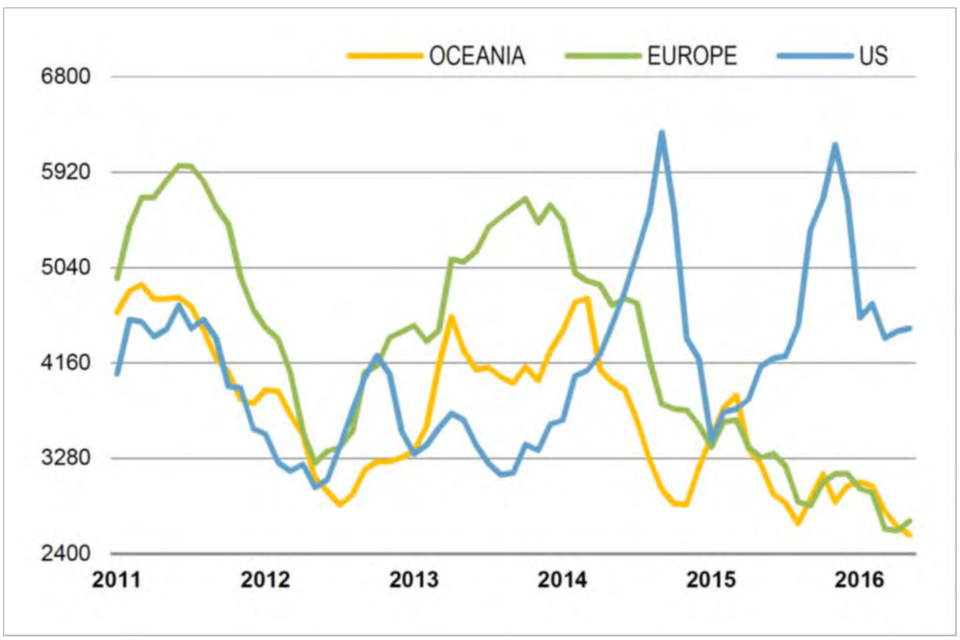

Figure 4. Estimated global butter prices ($/MT)
Source. Global Dairy Outlook, May 2016 (USDEC)

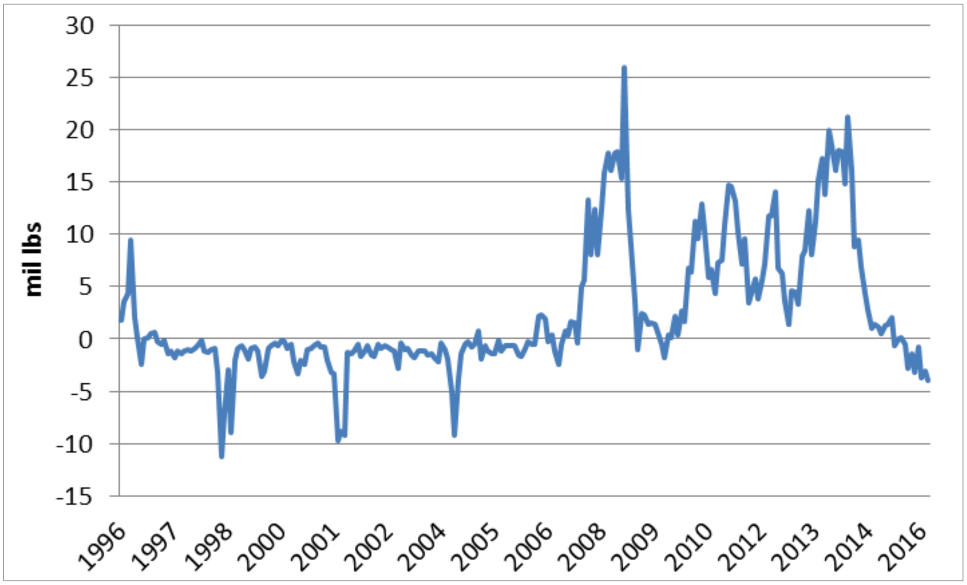

Figure 5. US butter net exports (Mil Lbs.)
Source. Foreign Agricultural Service –US Trade Data (www.usda.fas.gov)

Figure 6 shows the world and top five importers and the market share by major exporter. What's clear is in terms of the differential effect that Russia and China have had on the key dairy exporters, both New Zealand and the EU have been adversely affected (Figure 6). Russia was a key export market for the EU in 2014 and China and New Zealand have historically had strong ties in the global dairy trade market (Global Trade Atlas). The United States depends heavily on Mexico as a dairy export market.

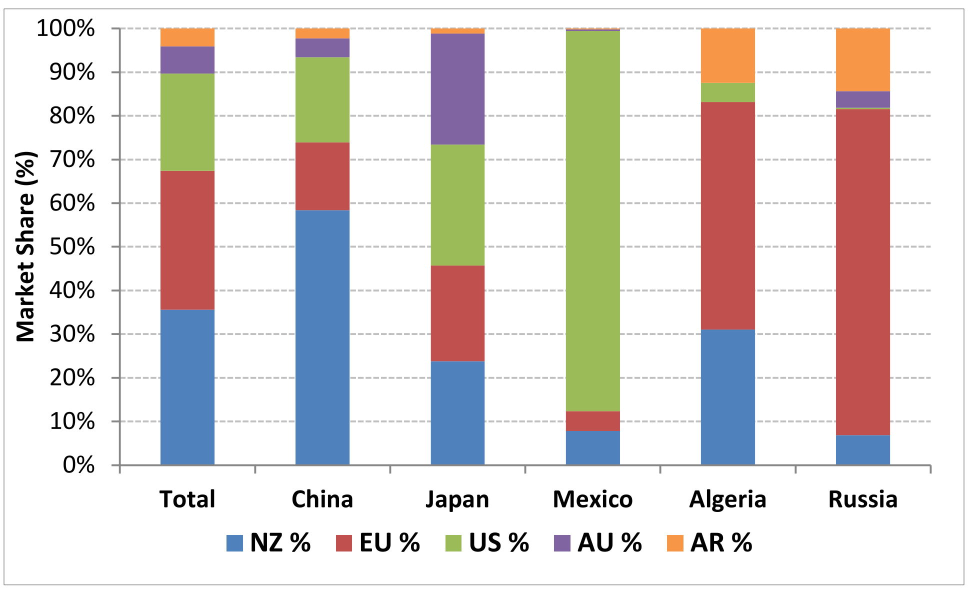

Figure 6. Source of global milk equivalent imports (2014)
Source. Global Trade Atlas (https://www.gtis.com/gta/)

World dairy exports are expected to remain flat throughout the remainder of 2016 (USDEC). Figure 7 shows the trend in aggregate export volume by the major dairy suppliers of SMP, WMP, cheese, butterfat, and whey. Exports from the United States are at a competitive disadvantage having to cope with the double-edged sword of higher prices compared to the EU or Oceania, as well as, a stronger currency.

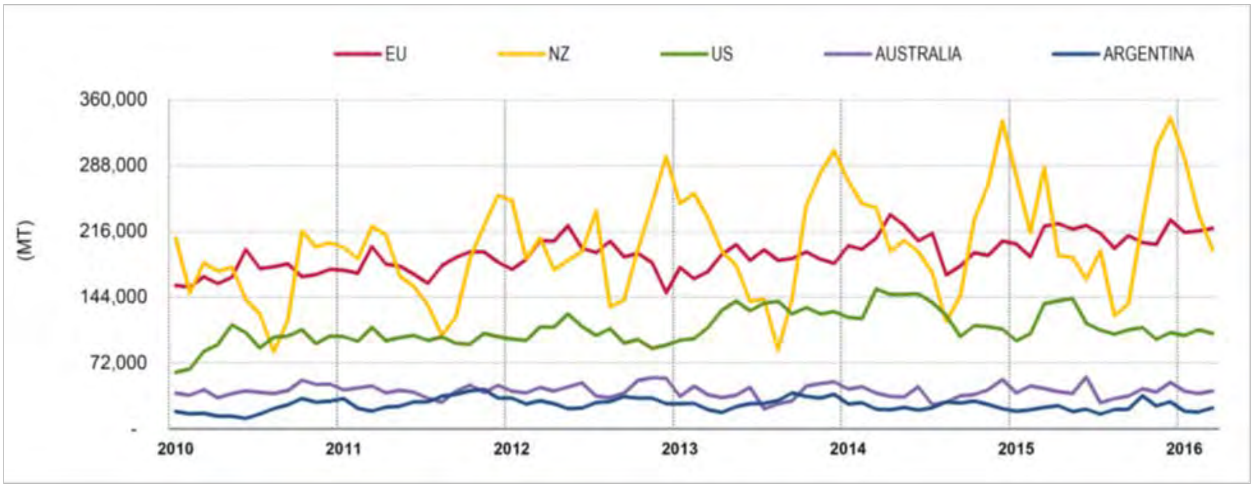

Figure 7. Aggregate export volume by major exporters
Source. US Dairy Export Council (www.usdec.org)

The weakening currency benefits competing exporters and makes their dairy exports more affordable relative to the US, but it also makes imported feed more expensive, so there is some potential downside as well in those countries (Figure 8). It is also important to take history into context. While the dollar has advanced in strength relative to the Euro and the NZ dollar, it is not near the exchange rates seen in the early 2000s.

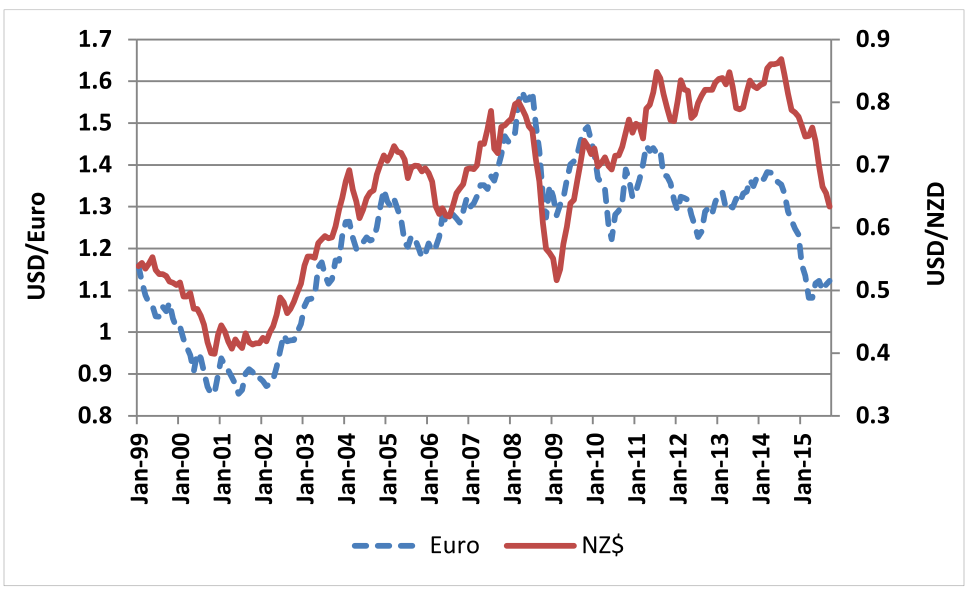

Figure 8. US dollar exchange rate history
Source. CME Group (http://www.cmegroup.com/trading/fx/)

US dairy exports have been growing both in volume and in their share of global trade over time (Figure 9). As exports become a more important part of the domestic US dairy industry, the impact of global trade and economic conditions becomes increasingly more relevant. Key markets for the United States include China, Mexico, Japan, S. Korea, and the Philippines are also key markets.

Figure 9. US export volume and share of global trade
Source. Global Trade Atlas (https://www.gtis.com/gta/)

While there has been strong growth in China, remarkable import growth has also been seen in Mexico as well as other international markets (Figure 10). Despite the remarkable growth in US dairy exports over approximately the last ten years, recent export volumes have been hit hard by the global dairy economic situation (Global Trade Atlas). The two largest export markets for the United States, China and Mexico, are lower in export value compared to last year according to the US Dairy Export Council.

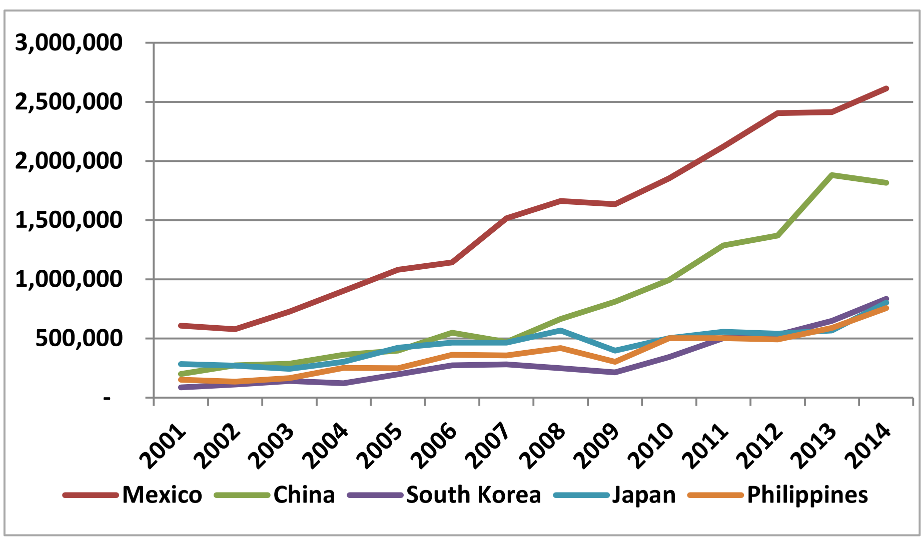

Figure 10. Top five US export destinations (MT)
Source. Global Trade Atlas (https://www.gtis.com/gta/)

In sum, the global dairy trade outlook points to a continued drop in prices until the oversupply imbalance is corrected. Potentially weak margins throughout 2016 should trigger a slowdown in global production of milk. It is anticipated that stronger import demand on the heel of low prices will follow global production cutbacks. Price recovery is not expected to before 2017. Key factors include the return of China to the import market, global weather conditions and a strong El Nino pattern, and the international macroeconomic situation.

Asia and Global Dairy Trade

In 2013, about one-third of global milk production was provided by Asia and Oceania (Figure 11). This share has been increasing for a decade due to the rapid expansion of dairy in the region, especially in China and India. In the past 10 years, Asian milk production grew on average about 4% annually, which represents the fastest growth of any other region and is considerably higher than the global annual growth rate of 1.8% (Table 1).

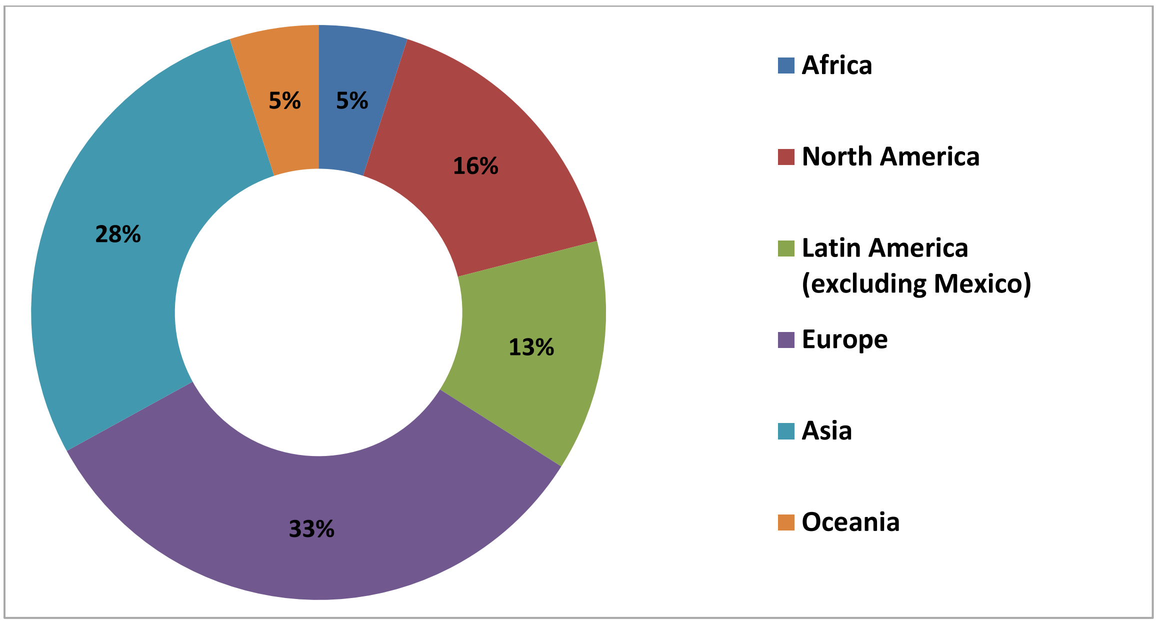

Figure 11. Share of global milk production by region (2013)
Source. FAOSTAT (http://faostat.fao.org/)

Such rapid growth is anticipated to continue over the next ten years and even countries like Japan and Australia which have had negative growth rates are expected to enter a positive growth phase (Figure 12). Key factors associated with the rapid expansion of dairy production in Asia include growing cow numbers and better yields due to improved management practices (Table 1).

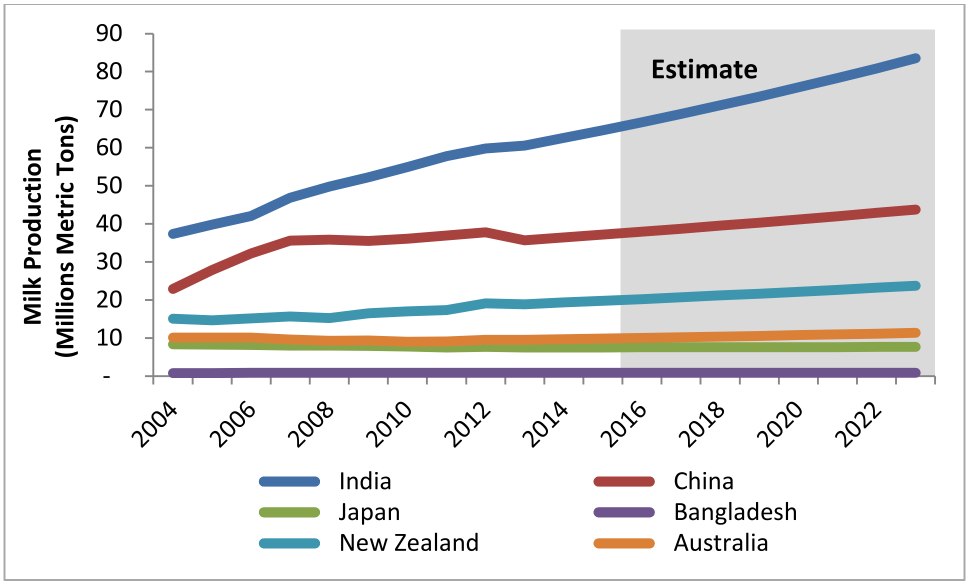

Figure 12. Growth in milk production
Source.OECDSTAT (http://stats.oecd.org/)

Table 1. Milk production and cows in milk –Compound Annual Growth Rates (CAGR)

	Cows Milk Production Thousand Cows			Cows in Milk Thousand Metric Tons		
Country	2013	CAGR 2004–2013	CAGR 2014–2023	2013	CAGR 2004–2013	CAGR 2014–2023
India	60,600.0	5.0%	3.3%	44,900.0	2.2%	1.6%
China	35,670.0	4.5%	2.1%	12,159.1	3.1%	3.1%
Japan	7,508.3	-1.0%	0.2%	992.1	-1.7%	-0.2%
Bangladesh	838.0	0.5%	0.5%	4,077.0	0.4%	0.4%
Indonesia	981.6	6.0%	2.3%	636.0	5.7%	0.8%
Vietnam	456.4	11.7%	2.7%	152.0	4.7%	4.7%
Myanmar	1,380.0	6.5%	6.5%	2,600.0	6.5%	6.5%
Cambodia	23.5	1.2%	1.2%	138.0	1.2%	1.2%

Sources. FAOSTAT, OECDSTAT (http://faostat.fao.org/; http://stats.oecd.org/)

Much of the attention in global markets tends to focus on China and India due to the size of their economies and growth rates. With respect to dairy, however, India does not participate in the global trade market although it is the world's largest single country producer of dairy (including both dairy cows and buffalo). Asian countries consistently rank in the top twenty of global importers of dairy products (Table 2). Several trends emerge from Table 2 including the rise of China as the largest global importer and the fall of Russia from the ranking (due to the import ban). Additionally, the importance of other Asian markets is evident which include Japan, Indonesia, Malaysia and the Philippines.

Table 2. Ranking of top 20 global dairy importers by volume (Asian countries highlighted)

Rank	2000	2005	2010	2015
1	Japan	Japan	China	China
2	United States	Russia	Russia	Mexico
3	Algeria	United States	Japan	Japan
4	Mexico	Mexico	Mexico	Algeria
5	Saudi Arabia	Algeria	Indonesia	Indonesia
6	Philippines	China	Algeria	United States
7	Malaysia	Saudi Arabia	Philippines	Malaysia
8	Thailand	Philippines	United States	Philippines
9	Indonesia	Indonesia	Saudi Arabia	Saudi Arabia
10	Canada	Thailand	Malaysia	UAE
11	Taiwan	Malaysia	Singapore	Egypt
12	China	Singapore	Vietnam	South Korea
13	Egypt	Canada	Egypt	Vietnam
14	Russia	Egypt	Australia	Singapore
15	Vietnam	Vietnam	Thailand	Thailand
16	Venezuela	Taiwan	South Korea	Australia
17	Brazil	South Korea	Venezuela	Taiwan
18	United Kingdom	Nigeria	UAE	Venezuela
19	Australia	Australia	Taiwan	Nigeria
20	Singapore	UAE	Canada	Canada

Source. Global Trade Atlas (https://www.gtis.com/gta/)

Asia is also playing an increasingly important role in dairy production. Table 3 shows the top twenty global dairy producing countries which comprise about 75% of the world's total dairy supply (FAOSTAT). India and Pakistan dairy production is heavily dependent upon buffalo milk production. Clearly, India and the United States are the dominant producers, although India is not a key global trader. Key producing countries in Asia include China, Pakistan and Russia. Interestingly, there is quite a bit of divergence when comparing the ranking of production with productivity (or milk produced per dairy animal). While some of the leading producers and global traders are also among the most productive (United States, Canada, Germany, Japan, and the Netherlands), many of the world's leading producers are also among the least productive (China, India, and Brazil). This is a critical distinction as it suggests the possibility for these under-productive countries to increase supply significantly by making improvements in cow productivity.

Table 3. Top twenty countries for milk production (2012)

Country	Percent Buffalo Milk	Percent Total World	Milk Prod (MT)	Cattle Milk/Cow (kg)	Total Milk Rank	Milk/ Cow Rank
India	55%	16.6%	120,000,000	1,196	1	79
United States	0	12.6%	90,962,099	9,849	2	4
China	9%	5.6%	40,499,500	3,001	3	54
Pakistan	64%	5.1%	37,045,000	1,263	4	77
Brazil	0	4.5%	32,304,421	1,417	5	75
Russia	0	4.4%	31,576,047	3,913	6	44
Germany	0	4.2%	30,506,929	7,280	7	16
France	0	3.3%	23,983,197	6,583	8	21
New Zealand	0	2.8%	20,053,000	4,003	9	43
Turkey	0.3%	2.2%	16,024,826	2,991	10	55
Poland	0	1.8%	12,667,773	5,189	11	35
Argentina	0	1.6%	11,815,000	5,388	12	31
Netherlands	0	1.6%	11,675,448	7,577	13	13
Ukraine	0	1.6%	11,260,102	4,431	14	40
Mexico	0	1.5%	10,880,870	4,536	15	39
Italy	1.8%	1.5%	10,772,027	5,921	16	27
Australia	0	1.3%	9,480,132	5,575	17	28
Canada	0	1.2%	8,450,000	8,817	18	5
Japan	0	1.1%	7,630,418	7,795	19	10
Uzbekistan	0	1.0%	7,195,480	1,791	20	70

Source. FAOSTAT (http://faostat.fao.org/)

Turning attention to a few individual countries, while India is the world's largest milk producer less than half of that milk comes from traditional dairy cows with the majority sourced from the country's large buffalo population. Also, already mentioned is that India is not a global player in that it does not actively import or export milk. India has imported significant volumes of dairy products during times of milk shortage; however, these have declined over time. The milk production sector is highly unorganized and is characterized by many individuals owning few animals. Nearly 50% of the herds come from an average herd size of 1–2 animals which leads to sub-optimal yields and management practices (McCully 2015). If the Indian dairy supply chain can become more formalized and efficient they would likely become a more influential global player. With respect to the key companies operating in India, they include Nestle and Amul. Nestle is a global company and has had a presence in India since the 1959 opening of their plant in Moga. Over time, the Moga plant has grown from an operation of 4,600 farmers producing 2,000 metric tons of milk to now more than 100,000 farmers producing more than 300,000 metric tons of milk (Nestle corporate website). Amul is operated by the Gujaret Cooperative Milk Marketing Federation and is the largest dairy company in India. In 2014 they reported annual revenue of $574 million and have the capacity to process 4.5 million liters of milk per day with infant formula being a large part of their business (Amul corporate website).

China is the third largest global milk producer after India. Strong demand and government support has rapidly expanded milk production over the past decade. Although buffaloes have a much greater presence in India and Pakistan, buffalo milk is still important to the Chinese industry (Table 3). Presently, the Chinese dairy industry is experiencing a rapid consolidation of the supply chain. The current situation of a many small-scaled farmers connected by a loose network, much like in India, is fading away as larger scale and more efficient farms become more commonplace (Rabobank 2013). While the New Zealand company Fonterra has long had a strong tie to the Chinese dairy industry, other key commercial players include Yili, Mengniu, Beingmate, and Frieslandcampina. The Inner Mongolia Yili Industrial Group Co. Ltd is the largest dairy company in China with a near 25% market share in 2014 (China Daily 2015). Yili had operating revenue of $8.8 billion in 2014 and a profit of $700 million. The China Mengniu Dairy Co. Ltd. is the second largest dairy company in China with a 21.6% market share (China Daily 2014) and an operating revenue and profit of $8.1 billion and $400 million, respectively.

Japan, while a modest producer of dairy does play an important role in global dairy trade. Given the practical resource constraints such as land availability and operating expenses, the Japanese dairy industry is limited to how much it can grow and it is highly protected by the national government through prohibitive import tariffs. Figure 13 shows the tariff rate in % that is applied on global traded dairy products. In fact, global tariffs for dairy are amongst the highest for all traded products with Japanese dairy tariffs second only to Canada.

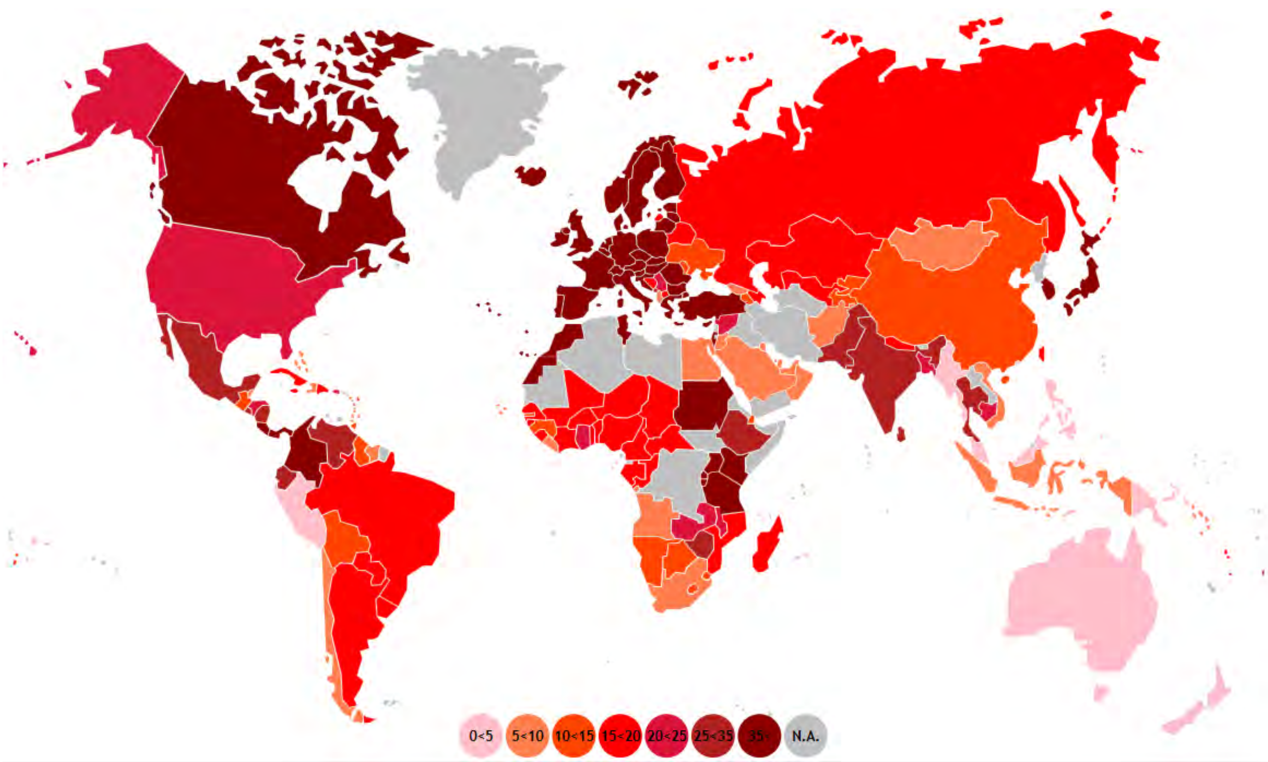

Figure 13. Global dairy tariff rates
Source. World Trade Organization (www.wto.org)

The implementation of the Trans-Pacific Partnership trade agreement is expected to significantly increase market access and import demand. Key commercial players include Meiji which ranked twelve on the Rabobank list of the twenty largest dairy companies with annual revenue of $7.4 billion (Rabobank 2014). Moringa with a global rank of twenty and revenue of $4.8 billion is another key Japanese dairy company.

Summary

The global and US dairy outlook remains bearish throughout 2016 with prices anticipated to have reached or be near reaching a low point. Fundamentally, increased global milk production led to an oversupply in exporting countries. Lower import demand from China and the Russian ban on dairy imports from several producing countries are key contributing factors. Moreover, the strengthening of the US dollar and a weakening of international currencies has dampened import demand. Lower global production is needed for market recovery. Stronger import demand on the back of lower prices could strengthen prices but this is not expected before 2017. The global outlook depends critically on China and unexpected weather events.

Lower prices spurred more imports in other markets but not near enough to counter declines by China and Russia. Overall, US exports are on an increasing trend both in volume and share of world trade. Major markets for the United States include China and Mexico while Japan, S. Korea, and the Philippines are also key markets. While there has been strong growth in China, remarkable growth has also been seen in Mexico as well as other international markets. Additionally, while the US dollar is gaining strength over Euro and NZ dollar, it is not at the level as was seen in the late 1990s and early 2000s.

Beyond the global dairy macroeconomic situation, the Asian dairy markets are becoming more relevant to the global trade space. While certain Asian countries are already dominant dairy producers, such as India, others have become key players in the import market, like China. Still, other countries in Asia are slated to continue to support global dairy trade and support increased import demand as their populations continue to grow and enter the middle class, including Indonesia, Vietnam, and the Philippines.

In summary the outlook for 2016 points to prices bottoming out until the oversupply imbalance is corrected. Weak prices throughout 2016 could trigger a slowdown in global production of milk. It is anticipated that stronger import demand on the heel of lower prices will follow global production cutbacks. While the Russian ban has been extended to late 2016, it is unknown if China will return to peak import demand levels. These factors will have a tremendous impact on the direction and magnitude of prices and exports in the short and long run. More long term, the outlook for the global dairy industry depends critically on the growth of dairy supply and demand in Asia which is increasingly playing an important role in the global dairy marketplace.

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Global Dairy Trade:
Where Are We, How Did We Get Here and Where Are We Going?

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Abstract

World trade in dairy products has grown in recent decades at rates that generally exceed demand growth in developed countries, which produce the majority of the world's dairy products. Data from the Global Trade Information Services (GTIS) online Global Trade Atlas trade data system and the United Nations Commodity Trade (UNcomtrade) Statistics Database show that total world dairy exports grew by 4.6% per year, on a milk equivalent basis, during 2010–2014 while total domestic consumption of dairy products in the United States grew by 0.9% per year during the same period, measured on the same basis (USDA/Economic Research Service 2016). The US dairy industry has participated significantly in this growth, increasing its exports from an estimated 5.3%of domestic milk solids production in 2002 to 15.5 % in 2013 and 15.3 % in 2014 (U.S. Dairy Export Council 2016). This article focuses on the factors contributing to this growth and discusses the current world dairy market situation and challenges the US dairy industry faces in an increasingly competitive export market environment going forward. It is intended to suggest some researchable questions that dairy economists and analysts might usefully examine to assist the industry's further progress in supplying the world's growing import demand for dairy products.

Keywords: global dairy trade, growth factors, future

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Demand Drivers

The expansion of world dairy trade has been primarily driven by growing demand in developing countries, as summarized in the following quote from an outlook report from the United Nations Food and Agriculture Organization (FAO 2003),

> As incomes increase, demand for greater food variety grows. Demand for higher-value and quality foods such as meat, eggs and milk rises, compared with food of plant origin such as cereals. These changes in consumption, together with sizeable population growth, have led to large increases in the total demand for animal products in many developing countries, and this trend will continue.

This quote would be an apt characterization of dietary changes in developing counties at any time during at least the past two or three decades. That these trends will continue, and continue to have significant implications for developed countries such as the United States, is suggested by recent economic projections by the Brookings Institution and recent production forecasts by the National Milk Producers Federation (NMPF) from domestic and world milk production data reported by the USDA National Agricultural Statistics Service and the United Nations FAOSTAT database. These projections indicate that the United States' share of the world's middle class population, defined as households with daily expenditures between US $10–$100 per person, fell below its share of world milk production in 2011, and that the US share of world consumption spending will drop below its share of world milk production in 2026. By 2030, the United States is estimated to produce just over 11% of total world milk production while its population will include just 4.5% of the world's middle class and account for about 9% of middle class consumption spending (Kharas 2010; FAOSTAT 2016; USDA/NASS 2016). Consumption spending by middle class consumers is the primary source of demand for milk and dairy products internationally. Similar trends are affecting other developed countries that produce the majority of the world's dairy products for export.

The United States dairy industry has become increasingly aware of the importance of exporting its products over the past two decades, as it has evolved gradually from a previous focus on preventing low-cost, typically subsidized imports from undermining its now-discontinued Dairy Price Support Program. An early indication of this focus was the founding in 1995 of the US Dairy Export Council, with the mission to enhance demand for US dairy products and ingredients by securing access and assisting suppliers to meet market needs that facilitate sales. This emerging export focus was further sharpened in 2009 and 2011 with the release and refresh of a commissioned study by the Innovation Center for US Dairy, including research and analysis conducted with the support and assistance of Bain & Company (Bain & Company 2011). The key finding of the report was that:

> Net import demand for dairy products would grow faster than net export supply through 2013, with demand growth coming primarily from developing economies in Asia, Latin America, North Africa and the Middle East. This will lead to a "latent demand gap" (global shortfall between consumption and production forecasts) of ~100,000 metric tons of dairy protein by 2013 (equivalent to ~7 billion pounds of milk). Importantly, the United States is a country that can be well positioned to capture the opportunity of filling the demand gap in the near term (10–15 years). Beyond this 10–15 year window of opportunity, new sources of low

> cost supply will deliver significant quantities—thus, there is a need to take action to ensure that US industry builds a long-term competitive advantage to ensure its place in the global market.

This concept of a latent demand gap in world markets was reaffirmed by a refresh of the original study in 2011, which also reiterated the recommendation that the US dairy industry become a consistent exporter of milk and dairy products to the global marketplace.

Most recently, a new study from the Research Institute of the international investment bank Credit Suisse (2015) conducted a comprehensive review of existing research on the health effects of dietary fat consumption, on the basis of which it predicted that a major change in global food consumption behavior was underway, concluding that:

> Globally, we expect fat to grow from the current 26% of calorie intake to 31% by 2030, with saturated fat growing the fastest and going from 9.4% of total energy intake to 13%. This implies that fat consumption per capita will grow 1.3% a year over the next fifteen years versus a rate of 0.9% over the last fifty years. We expect saturated fat to grow at 2% a year versus a historical rate of 0.6% a year. … Among foods, the main winners are likely to be eggs, milk and dairy products, (cheese, yogurt and butter) and nuts, with annual rates of growth around 2.5–4%.

Consumption patterns in the United States are already reflecting this predicted shift. If these predictions are borne out globally, it will have major implications for world dairy trade patterns and US dairy exports.

Trade Policy Drivers

Policy changes have also facilitated growth in world dairy trade. The Uruguay Round of multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT), 1986–1994, established binding limits on the use of agricultural export subsidies and domestic agricultural support regimes, converted all non-tariff import restrictions on agricultural products to bound tariffs, established science-based disciplines on the use of sanitary and phytosanitary (SPS) measures as trade barriers, and created the World Trade Organization (WTO) as a more effective international institution to resolve trade disputes and conduct negotiations to further liberalize world trade rules. The Uruguay Round came into force during a time when many developed country governments were reevaluating the budgetary cost of their domestic and export subsidy policies toward agriculture, and dairy in particular. One result has been that use of direct dairy export subsidies, at least by developed countries, has virtually disappeared during the past decade or so. Shortly after the Uruguay Round Agreement on Agriculture was implemented, Canada attempted to circumvent the Agreement’s export subsidy disciplines on dairy products by extending its dual-price, Special Milk Class program to include an export-dependent Special Class 5(e) price regime. The US dairy industry successfully challenged this program in two separate dispute settlement actions in the WTO in the late 1990s and early 2000s, which resulted in a WTO Appellate Body determination that this system constituted an export subsidy whose use was subject to the quantitative and monetary limits of Canada’s commitments on export subsidies. The importance of this action stems not only from Canada’s subsequent action to discontinue this program, but also because it prevented the European Union from adopting a similar system that it was contemplating at the time. The adoption of export class pricing systems for dairy products would have had a substantial effect of undermining the WTO export assistance disciplines for dairy products because such systems would operate without government funding; they require only government action, which fortunately was sufficient for the WTO to determine that they were indeed export subsidies.

The WTO disciplines on dairy trade were much less complete with respect to tariffs, which remain high for most developed countries, and with respect to the Agreement on Sanitary and Phytosanitary Measures, given the significant level of misuse that continues for such measures. The Doha Round multilateral negotiations under the WTO was launched in 1999 with the purpose of strengthening these and other disciplines, but this effort has stalled in recent years. The WTO membership has greatly expanded since the conclusion of the Uruguay Round, in numbers of members but much less so in volumes of trade. The much larger number of players, the WTO's consensus-based decision-making, and the somewhat conflicting goals of further liberalizing world trade and using trade as a development strategy have all combined to make progress in the Doha Round agenda extremely difficult. Countries interested in further trade liberalization have naturally shifted their focus to bilateral and regional trade agreements. Such agreements are not only relatively easier to negotiate, but the WTO disciplines on their use are also very accommodating (negotiating a lower tariff in a bilateral trade agreement effectively impairs the benefit to WTO members who are not parties to the agreement of a tariff bound in the WTO at a higher level. WTO rules consider such arrangements beneficial if they cover substantially all trade but less so if they exclude major sectors of trade, as many do).

The first bilateral trade agreement that affected the US dairy industry was the North American Free Trade Agreement (NAFTA), which eliminated tariffs on trade in all dairy products between the United States and Mexico. Canada was a party to most portions of the NAFTA, but refused to make any market access concessions on dairy and poultry, sectors subject to strict supply-management controls in Canada. The NAFTA rules of origin treat Canadian dairy components as if they originated in a non-party to the NAFTA. NAFTA provided the first platform for the dairy industry to challenge Canada's strict import controls on dairy products. Under the earlier, and pre-WTO, US–Canada Free Trade Agreement, which was incorporated into the NAFTA, the United States and Canada agreed to eliminate all existing tariffs on bilateral trade in dairy products, but each retained the right to continue to apply their respective non-tariff market access restrictions to dairy products. These consisted of the import quotas imposed under the authority of Section 22 of the Agricultural Adjustment Act, for which the US had a waiver of applicable rules under the pre-WTO General Agreement on Tariffs and Trade (GATT), and Canada's import control list, which was sanctioned under GATT Article XI. Both the United States and Canada surrendered the ability to apply these non-tariff measures when they were converted to bound tariffs in the form of Tariff-Rate Quotas (TRQs) under the WTO Agreement on Agriculture. In the mid-1990s, the US dairy industry brought the first complaint under the dispute settlement procedures of Chapter Twenty of the then-new NAFTA, arguing that the prior agreement to eliminate all tariffs on dairy under the NAFTA/US–Canada FTA applied to Canada's new and egregiously-high tariffs on dairy in the WTO. The Arbitral panel convened to adjudicate the case ruled in favor of Canada, declaring that because Canada did not intend to eliminate its tariffs on US dairy imports when it reluctantly agreed to tariffication in the WTO agriculture agreement, the NAFTA disciplines did not require them to do so, regardless of the plain meaning of the text. The episode exposed the relative weakness of the NAFTA dispute settlement mechanisms, particularly the means of selecting arbitral panels, compared with the much stronger WTO dispute settlement rules and procedures.

The United States has subsequently entered into free trade agreements with an additional seventeen countries, primarily dairy-importing ones, under which tariffs on dairy trade have been, or will be eliminated. The most recent such agreement is the recently-concluded, as yet unratified Trans Pacific Partnership (TPP) agreement. Under the TPP, the US would both give and receive market access concessions, primarily with respect to TPP members New Zealand, Japan and Canada, the latter providing the first-ever such concessions that could benefit the US dairy industry.

Price Drivers

The world market had been a relatively unattractive place for US manufacturers and marketers of dairy products until approximately a decade and a half ago. Prior to then, world prices, and hence financial returns to dairy product exporting, were well below comparable prices and returns from sales in the US domestic market. Dairy policy in the United States has never relied heavily on regular use of export subsidies to deal with domestic dairy product surplus situations. Instead, the primary mechanism of US stabilization, or safety net policy, was market intervention through the Dairy Price Support Program to remove surplus products from US commercial markets and inventory them domestically until recovering prices permitted them to be sold back into commercial markets or diverted to non-commercial uses. During the later 1980s, the US Department of Agriculture did make extensive below cost export sales of the large stocks of dairy products it acquired under the Dairy Price Support Program in the late 1970s and early 1980s. The Congress enacted the Dairy Export Incentive Program (DEIP) in the mid-1980s, which the Department of Agriculture fully implemented in the late 1980s and early 1990s, but its use was always relatively small compared with the size of the US dairy industry.

The European Union had long faced the same domestic-world price difference, but, by contrast, chose to rely more heavily on export subsidies to manage its surplus milk production, with a smaller role assigned to domestic intervention and domestic storage of surplus products. As a result, European dairy companies have for a long time sold relatively large volumes of dairy products to other countries, and in the process have acquired extensive experience in exporting dairy products and built extensive export marketing networks, long before exporting dairy products was commercially viable without government assistance. When the Uruguay Round Agreement on Agriculture was fully implemented in 2000, use of export subsidies by all WTO members was limited to percentages of both product volumes and monetary outlays during a designated period during 1986–1988. Under the agreement, the EU was permitted to use by far the largest product volumes and expenditures to subsidize the export of dairy products, which it subsequently used to maintain its large dairy export sales volumes. However, as the decade of the 2000s progressed, EU governments reassessed the budgetary cost of financing those export volumes and began to curtail their expenditures for doing so. The last time the EU exported dairy products with direct government assistance was in 2009, as did the United States, which had long provided government export assistance to export dairy products primarily in response to the EU's use of the same. By that time, growing world demand for dairy products and diminishing use of export subsidies had resulted in a gradual rise in world prices for dairy products toward parity with the commercial cost of supplying those products by US and EU dairy companies.

During this time, the dairy industries in New Zealand and, to a lesser extent, Australia were generally able to maintain and grow their dairy exports without large-scale government expenditures, and were the early beneficiaries of the gradual improvement in world prices of dairy products over the past two decades.

Current Competitive Situation

The period of significant growth of US dairy exports, of the gradually narrowing gap between world dairy product prices and corresponding domestic prices in the United States and the European Union, reached a crescendo in 2013 and 2014 when China experienced a significant shortfall in its growing domestic supply of milk and embarked on a program of massive purchases of dairy products, primarily whole milk powder, from export suppliers. Following the melamine contamination crisis of several years ago, China had been engaged in a large-scale effort to replace its fragmented, small farm-based milk production sector, with its weak quality controls, with a more centralized system of large farms and greater control over its supply chain. The change-over was slower than expected, as the new larger dairy farms were slow to gear up to efficient production and the influx of dairy cows from the exiting small dairy producers proved smaller than expected because high beef prices caused many of them to sell their cows for slaughter rather than to larger dairy farms. China's large dairy purchases occurred at a time when milk production in the United States, the EU and New Zealand was not growing, and the resulting supply-demand situation pushed dairy product prices to historic highs around the world. However, China severely scaled back its dairy purchasing in early 2014, after having acquired very substantial stocks. World dairy product prices almost immediately began a long slide to much lower levels, from which they have not yet recovered.

The depressed world dairy product price and trade situation of 2014–2016 represents something of a break or reset point in the evolution of world dairy trade. It represents the end of the "latent demand gap" period of demand-led export growth and the commencement of a period of heightened competition among export suppliers. The current world dairy trade situation is broadly described in the following excerpts from a recent joint outlook report from the Organization for Economic Cooperation and Development and the FAO (OECD–FAO 2015):

> In real terms, prices for all agricultural products are expected to decrease over the next ten years, as on-trend productivity growth, helped by lower input prices, outpaces slowing demand increases. ... Demand will be subdued by per capita consumption of staple commodities approaching saturation in many emerging economies and by a generally sluggish recovery of the global economy. …consumers (will continue) to diversify their diets by increasing their consumption of animal protein relative to starches. For this reason, the prices of meat and dairy products are expected to be high relative to the prices of crops. … Exports of agricultural commodities are projected to become concentrated in fewer countries, while imports become more dispersed over a large number of countries. The importance of relatively few countries in supplying global markets for some key commodities increases market risks, including those associated with natural disasters or the adoption of disruptive trade measures. … Exports of dairy products are projected to further concentrate in the four prime origins: New Zealand, the European Union, the United States and Australia, where opportunities for domestic demand growth are limited.

Trade data for the major internationally-trade dairy products from GTIS and UNcomtrade supports the OECD-FAO (2015) assessment that dairy exports will continue to concentrate, although more likely among the top three rather than the top four key players, as shown in the following table.

Table 1. Four key players in the global dairy trade

Share of Global Dairy Exports (ME)	2010	2011	2012	2013	2014
Australia	6.3%	5.6%	5.8%	4.9%	4.9%
EU-28 (extra-EU trade)	26.1%	26.1%	26.3%	24.5%	27.3%
New Zealand	25.6%	26.2%	27.9%	27.0%	28.9%
United States	15.7%	15.7%	15.0%	17.5%	17.7%
Subtotal, above four	**73.7%**	**73.6%**	**75.0%**	**73.8%**	**78.8%**
Total, all countries	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The United States and the European Union have both made major changes in dairy policies at about the time of the current transition in the world dairy trade situation. The US discontinued its long-standing Dairy Price Support Program and replaced it with the milk price-feed cost margin insurance program, the Margin Protection Program, in the 2014 farm bill. The events of 2009 demonstrated to the industry how fundamentally incompatible a purchase and inventory-based dairy policy is with an export growth-led marketing strategy. Following its slow decline as an export supplier of dairy products, and facing sluggish growth in its members' domestic economies, the ending in early 2015 of EU-wide milk production quotas and the embargo of its exports to Russia, the EU dairy industry has refocused on world markets. EU dairy companies, particularly those in northern Europe, have made major investments in processing capacity geared toward export markets and are actively seeking to increase their world market share. New Zealand has continued to grow its milk production and dairy exports, which represent most of its dairy production and a substantial fraction of the country's foreign exchange earnings.

These big three dairy exporters exhibit a variety of structural features and policies that affect their export competitiveness, the differences among which will likely be sharpened in the increasingly competitive world dairy markets going forward for the next several years.

In the United States, the Western states are more exposed to world dairy trade than those in the Midwest and the East, due to the relative mix of products that determine milk prices paid to producers in the different regions. Western states originate a substantial portion of US skim milk powder and other nonfat milk solids-based exports. The balance between supply and demand in the US dairy industry has usually been tighter on a milkfat component basis than on a skim solids one. Historically this has been balanced through sales of nonfat dry milk to the Commodity Credit Corporation under the Dairy Price Support Program. But over the past decade or so, skim solids-based products not needed to supply domestic market needs have increasingly been exported commercially. Exports of skim milk solids in all products increased from an estimated 6.7 % of domestic skim milk solids production in 2002 to 19.4 % in 2013 and 19.2 % in 2014. By contrast, exports of milkfat in all products increased from an estimated 1.8 % of domestic skim milk solids production in 2002 to 6.4 % in 2013 and 6.3 % in 2014. The steep slide in world milk prices during 2014 and 2015 has particularly affected domestic nonfat milk solids component prices, which make up a larger proportion of the milk prices received by milk producers in the West, compared with their counterparts in the central and eastern United States.

The somewhat regionally-divergent price impacts of world dairy trade in the United States will prove temporary as world prices recover. By contrast, regional differences within the European Union are more fundamentally structural and will have longer-lasting effects in the more globally-exposed EU dairy industry going forward. Milk production in the Northern tier of EU member-states will grow at the expense of more southern parts of the EU dairy industry in the post-milk production quota marketing environment. The New Zealand South Island, which has experienced relatively rapid milk production growth in recent years, but at higher cost, has been more heavily affected by the drop in world prices.

There are substantial policy differences among the three dominant world dairy exporters that will play a key role in determining the outcome of their intensifying competition in the current world dairy trading environment. In New Zealand, Fonterra Co-Operative Group Ltd., formed by the merger of the previous state export monopoly New Zealand Dairy Board and the two largest domestic dairy cooperatives, continues to handle the overwhelming majority of the country's dairy exports and thereby avail itself of the price pooling power and flexibility that such a commanding share of national exports confers. But the country lacks a domestic market of the scale which allows the US and the EU to buffer the impact of low world prices. Both the EU and New Zealand have long used policies and strategies to keep exports flowing during periods of surplus milk production as opposed to building domestic inventories of dairy products at such times. The United States, as previously discussed, is a relative newcomer to the marketing strategy of avoiding building inventories during periods of price weakness and instead ensuring that product continues to flow to international buyers during such periods. Discontinuing the Dairy Price Support Program represented an important step in this evolution, but other policy issues remain.

Most milk in the United States is subject to price pooling under federal and state milk marketing orders. Under marketing orders, pooled milk is subject to minimum pricing at price levels which largely reflect its value when manufactured into products sold at domestic prices. Export sales often require pricing that is competitive with that of other export suppliers at the importer's point of purchase rather than with other sellers in the US domestic market. Competitive prices can differ in these two different markets, particularly for cheese, butter and other milkfat products, of which the US exports a relatively small share of its total production and for which the US supplies a relatively small share of total world exports. It is for this reason that the US industry developed the voluntary Cooperatives Working Together (CWT) program, which has provided assistance to US exports of cheese, milkfat and whole milk powder since 2003.

By contrast, milk marketed in the European Union is not subject to regulated minimum prices and market-wide pooling. The large EU dairy companies, both cooperative and proprietary, therefore have a relatively greater degree of internal pricing flexibility in their competition with US exporters. EU companies do not have to pay for milk used to produce products for export at a price equivalent to domestic product prices; they only have to pay an average price for milk sold in all markets that is competitive with other EU milk buyers and processors, many of whom are also competing in world markets for additional sales. Over the past year or two, this has resulted in EU dairy companies paying lower prices for milk than US companies, but increasing their market share in the major US export markets for butter and cheese, at the expense of US sales. This is essentially what happened to the US dairy industry, only in much more dramatic fashion, in 2008 and 2009.

Most of the milk produced in New Zealand is sold in product form outside the country and is therefore priced effectively at world market levels, particularly the majority of the country's milk that is marketed by Fonterra. Accordingly, milk prices received by New Zealand dairy farmers have been much lower than prices received by either US or EU dairy farmers during the current world price slump. Fonterra prices milk to its producers under an annual pooling arrangement internal to the company. Sales at the margin can be made at virtually any price but the resulting revenue constitutes a very small portion of the season average of all such sales, which constitutes the final price paid to its producers at the end of the season, or final payout. During periods when world dairy product prices are not particularly depressed, this system, like the payment systems in the European Union, can provide both decent payouts to New Zealand farmers as well as great flexibility for maintaining or increasing market share in dairy importing countries in competition with US dairy exporters.

Final Remarks

The United States dairy industry is embarking on a new, and more challenging phase of its heretofore successful evolution into one of the top players in the global dairy industry. It has made substantial commitments to becoming a reliable supplier of high quality dairy products to world markets, and it has made substantial adjustments to marketing programs and to policies in order to do so. But to maintain and expand that role, the industry, and its individual players, will have to intensify further that commitment and to continue to examine and adjust those programs and policies to enable them to do so.

The community of US dairy economists and analysts has played a relatively minor role in the first phase of this development, to date. But there is a very rich set of researchable questions that this community should see as its responsibility to address, to more actively provide insights into, and to facilitate, the industry's next phase.

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The Effects of Panama Canal Expansion on US Dairy Trade Flows: West, East, and Gulf District Regions

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Abstract

In the last two decades, many trends and policy developments impacted the course of the US dairy industry. Since the mid-1990s two important trade agreements, NAFTA and Uruguay Round have increased international trade for the dairy industry. As of 2015, a major transportation improvement is expected to be achieved by to the expansion of the Panama Canal. The canal is expected to lower transportation costs for many exporters. In this study, we develop a world dairy trade model to analyze dairy product export quantity from the three dairy producing US regions: west coast, gulf coast, and east coast and great lakes combined. We assess the effect of the Panama Canal expansion on the trade of the US regions. We find that the west coast, which includes California, Oregon, Washington, and Idaho states, is one of the biggest beneficiaries of the expansion. The competitive advantages of this region aid in harnessing the most benefits from the transportation improvements and international demand growth for dairy products.

Keywords: dairy products trade, regional trade analysis, Spatial Equilibrium Model

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Introduction

In the last two decades, many trends and policy developments impacted the course of the US dairy industry. Since the mid-1990s two important trade agreements, NAFTA and the Uruguay Round, have propelled the dairy industry into international trade growth phase (Nicholson and Bishop 2004; Cox et al. 1999; Bishop and Novakovic 1994). In addition to the expansion into the North, Central, and South American markets, US dairy product exports have significantly increased to the East and Southeast Asia as well as some Oceanian countries due to the economic development and the trade liberalization in these regions.

In this study, we consider dairy product trade from the three dairy producing US regions: West Coast, Gulf Coast, and East Coast and Great Lakes combined.[1] The delineation of regions was chosen based on the custom districts used for exporting dairy products as defined by Foreign Agricultural Service (USDA–FAS 2015) and US Dairy Export Council (USDEC 2014). The East Coast and the Great Lakes regions were combined as US East Coast after consideration of key gateway routes between these two regions and custom districts, located on the east coast (USDEC 2014).

Large dairies in the West Coast region have been steadily increasing their share of US milk production over the last four decades due to abundant alfalfa and other inexpensive feeds (production of which uses subsidized irrigation), excellent weather for dairy cattle and ability to build large dairies (Day 2013). However, recent droughts in the years 2013 and 2014 in the West have brought some challenges and stunted the growth experienced in the previous years.

Next, we witness growth in the Upper Midwest, Eastern Wisconsin, Michigan, and Western New York, which comprise the East Coast and Great Lakes region in this study. Availability of water, cool climate, and quality feeds are among the main reasons of this increase. In the Gulf Coast region, large increase in milk production has been observed around Texas and New Mexico border due to favorable climate. However, production in other southern and southeastern states suffers from humidity levels that do not allow cows to fully express advances in their genetics associated with high milk yield.

Latest statistics show that the West Coast is one of the biggest beneficiaries of the recent trends and policies in trade. The competitive advantages of this region aid in harnessing the most benefits from the expansion in trade policies and international demand growth for dairy products. The advantages include favorable geographic location relative to the transportation routes as well as land and resource base that is highly conducive for dairy production. The regions' proximity to international water transportation routes and efficient domestic transportation via regional rivers systems leading to the export terminals translates into lower transportation costs and allow competitive product pricing.

[1] The category of west coast includes California, Oregon, Washington, and Idaho states. Gulf districts consist of Texas, New Mexico, Missouri, Louisiana, Arizona, and Alabama states. East Coast & Great Lakes regions combined consists of New York, Maryland, Connecticut, New Jersey, Maine, Rhode Island, Vermont, Virginia, West Virginia, Carolinas, Georgia, Florida, Illinois, Ohio, Michigan, Minnesota, Wisconsin, and North Dakota states.

However, the expansion of Panama Canal, which intends to double its capacity in 2016, is expected to increase the tonnage carried by dry bulk and refrigerated cargo, and hence, the competitiveness of dairy exports out of the East and Gulf Coasts (Harrison and Trevino 2013). Therefore, we investigate the effect of the Panama Canal expansion on trade from the three US regions.

Panama Canal expansion would decrease transportation cost from US Gulf ports to Northeast Asia by 13% (US Maritime Administration 2013) and from the East Coast to East Asia by 10% (Schneider 2015). The reduction in transportation costs have been largely attributed to the ability of the larger container vessels to pass through Panama Canal. For instance, the current choice of a vessel is Panamax, which is 294 meters long with a 12-meter draft, while the new choice would be Post Panamax which is 366 meters long with a 15-meter draft (Panama Canal Authority 2015).

Overall, this study evaluates the effects of the Panama Canal expansion on the exporting producers from the three dairy producing regions—West Coast, Gulf Coast, and East Coast and Great Lakes districts combined—due to their competitive advantages. We find that the west coast has a number of attributes and factors of endowment that make it one of the most competitive regions for dairy product exports.

Overview of the US Regional Dairy Trade

In 2014, the US dairy industry accounted for about 10% of total farm cash receipts (USDA–ERS 2015). As of 2014, the US total export value of dairy is about $5.5 billion (USDA–FAS 2015). Figure 1 demonstrates that from 2010–2014 the US the total milk powder and butter export quantities worldwide have increased significantly—by 134% and 127%, respectively, and total dairy export values of milk powder and butter grew by 91% and 39%, respectively (USDA–FAS 2015). The US exported 78% of the milk powder produced while the export shares of butter and cheese were 9% and 7% in domestic production, respectively (Table 1).

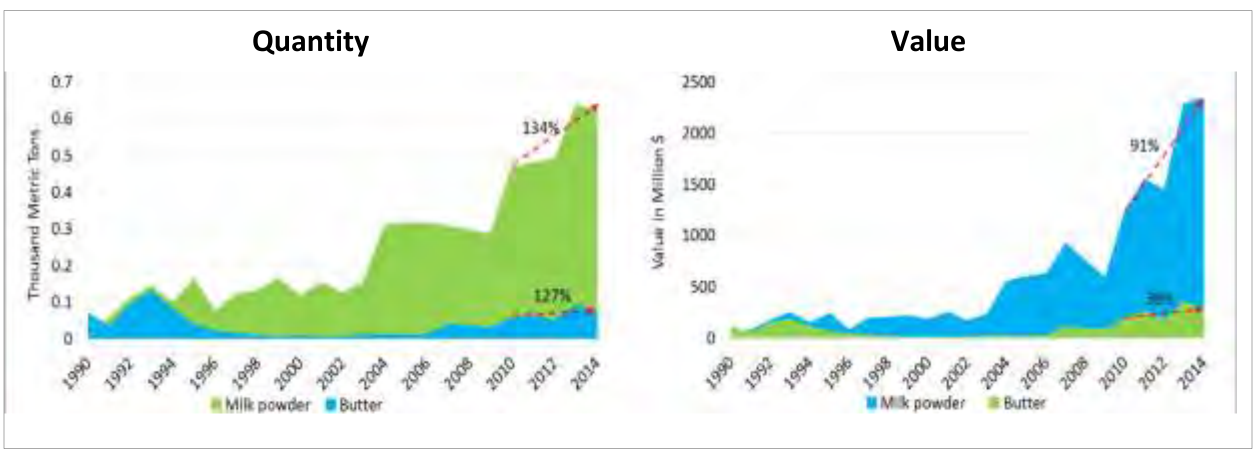

Figure 1. Worldwide trends in US dairy export quantity and value, 2010–2014

Table 1. US domestic production and export amount in 2014

	Domestic Production (Metric Ton)	Export (Metric Ton)	Share
Butter	844,630.15	72,185.30	8.55%
Milk Powder	802,852.05	626,774.90	78.07%
Cheese	5,274,205.53	368,728.50	6.99%

Note: The data is collected from USDA and all figures are converted to metric ton by the authors.

The analysis of the export value of each product from each of the three regions to the world shows that, from 2010 to 2014, US Gulf Coast districts experienced the highest export growth in quantity for milk powder (80.9 TMT), followed by West Coast district in milk powder (58.7 TMT), East Coast districts in milk powder (19 TMT), and West Coast in butter (11 TMT) (Table 2).

Table 2. Trade flows of dairy product exports in Thousand Metric Tons (TMT) from US regions.

US Regions	Dairy Products	Average (2010-2014)	2010	2014	Difference from 2014 to 2010
US West Coast	Milk powder	310.9	298.9	357.6	58.7
US Gulf Coast	Milk powder	200.5	145.1	226.0	80.9
US East Coast	Milk powder	28.5	22.7	41.7	19.0
US West Coast	Butter	42.5	33.7	44.7	11.0
US Gulf Coast	Butter	7.1	11.3	6.3	-5.0
US East Coast	Butter	17.0	11.8	21.1	9.3

Note. Figures are calculated by the authors from USDA–FAS (2015).

The export values for milk powder and butter from the West Coast have grown at larger figures than those of the national total for the same products. In contrast, the exports of butter from Gulf Coast districts have contracted with a loss of 12.4 million dollars in the exports in butter. The West Coast districts have had smaller increase in the export values of milk powder ($83.1 M) and a comparable significant increase in the export values of butter with $38.2 M (Table 3).

Table 3. Trade flows of dairy product exports in million dollars from US regions.

US Regions	Dairy Products	Average (2010-2014)	2010	2014	Difference from 2014 to 2010
US West Coast	Milk powder	1,028.8	791.1	1,366.3	575.1
US Gulf Coast	Milk powder	652.9	380.0	833.7	453.7
US East Coast	Milk powder	87.3	57.4	140.5	83.1
US West Coast	Butter	164.8	120.1	173.2	53.1
US Gulf Coast	Butter	23.6	36.7	24.3	-12.4
US East Coast	Butter	65.2	45.2	83.5	38.2

Note. Figures are calculated by the authors from USDA–FAS (2015).

Next, it is also important to understand which partner countries exhibited the most import demand for these products. Out of all product-specific bilateral trade flows with either five-year-average or 2014–year trade quantity larger than a Thousand Metric Tons (TMT), the following products have experienced significant export growth: butter from the West Coast to East Asia, milk powder from the East Coast to Southeast Asia, butter from East Coast to Africa, milk powder from the East Coast to East Asia, milk powder from the West Coast to North America. Despite already sizeable 2014 and five-year average volume of trade, the West Coast has grown exports of milk powder to East Asia. In addition, some regions have remarkable increase in trade flows such as butter from East Coast to Southeast Asia and milk powder from East Coast to Oceania (Table 4).

Table 4. Bilateral trade flows from US regions.

Export District	Import Country	Product	2010	2014	Five-year average
US West Coast	East Asia	Milk powder	29,694	75,377	49,258
US West Coast	East Asia	Butter	3,287	6,491	5,316
US East Coast	Southeast Asia	Milk powder	243	13,691	2,914
US East Coast	Africa	Butter	712	5,047	2,580
US East Coast	East Asia	Milk powder	310	894	1,120
US West Coast	North America	Milk powder	241	2,001	1,088
US Gulf Coast	Southeast Asia	Milk powder	119	3,842	796
US East Coast	Southeast Asia	Butter	13	1,829	686
US East Coast	Oceania	Milk powder	37	1,483	403

Notes. Figures are calculated by the authors from USDA–FAS (2015).

Judging by the five-year average value of exports, the ascending top bilateral trade in the order of value of exports are: butter ($30.5 billion) from the West Coast to Africa, butter ($21.8 million) from the West Coast to East Asia, butter ($16.3 million) from the West Coast district to Europe, and butter ($10.2 million) from the East Coast to Africa (USDA–FAS 2015). All have experienced at least 30% growth rate from 2010 to 2014 (Figure 2). However, butter ($19.2 million) from the Gulf district to North America, and butter ($12.3 million) from the East Coast to North America experienced a decline in export values (USDA-FAS 2015).

Both the export values and growth rates from the west coast are the largest compared to other regions and US total. In the light of the past and future trends, this study aims to compare the differences in the dairy production regions in the United States and analyze the competitive advantages of US regions' dairy exports to international markets given the transportation improvements that will come with the expanded Panama Canal, which will allow for a decrease in shipping costs due to the capacity to use much larger ships also known as post-Panamax vessels.

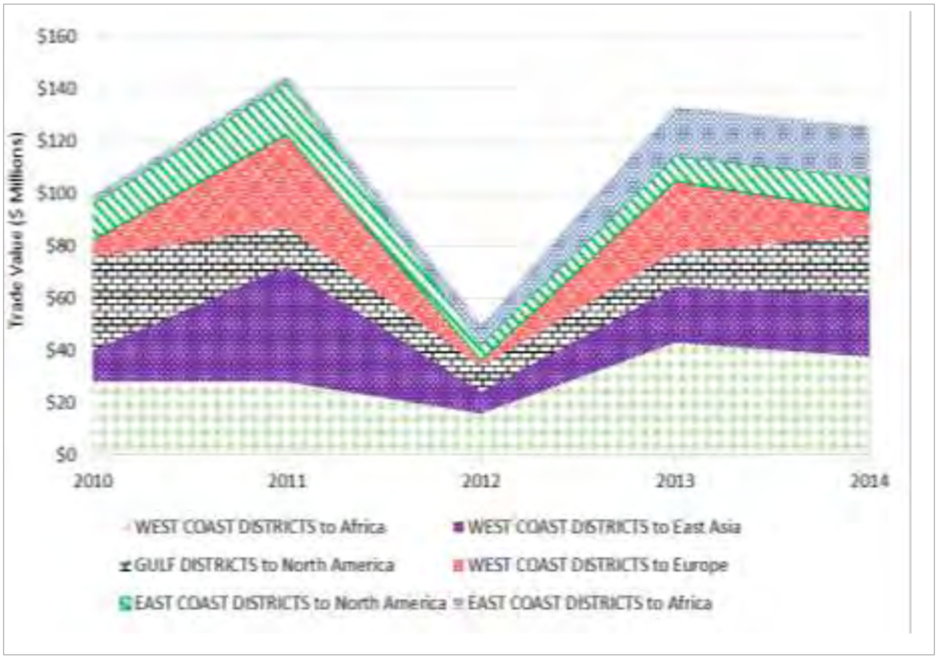

Figure 2. Top regions and export destinations for butter (export value), 2010–2014

Panama Canal Expansion

Panama Canal historically has had a strategic importance in terms of the development of engineering skills and independence of Panama. It has also been an economic asset to the United States. Canal has transformed the patterns of shipping, and saved approximately 7,800 miles by ocean on a trip from New York to San Francisco by eliminating the dangerous passage from the southern tip of the continent. It is a major shipping access route bearing two-thirds of the transits originating from and arriving to the US ports (Bridges 2012). More than 14,000 ships travel through the canal each year (Mitchell 2011). Seventy percent of the containerized freight is coming in or going out from the US East Coast (Knight 2008).

The increase in the liberalization of trade and the growing economy in the Asian countries have increased the demand for an expansion of and/or alternative canal for Panama Canal. In 2006, the Panama Canal expansion project was proposed to double the capacity of the Panama Canal by 2016. As of March 26th, 2016, 97% of the work has been completed, and the canal's opening date is scheduled for June 26, 2016 (Panama Canal Authority 2016). This expansion is intended to create a new lane of traffic and will handle much larger vessels, the Post Panamax size, which are about one and a half times the current maximum width and length (known as Panamax) and can carry over twice as much cargo (Panama Canal Authority 2015).

For example, before the expansion the largest vessel that could pass the canal was Panamax that was 965 feet long, 106 feet wide with a draft of 39.5 feet and handled 4,500 twenty foot equivalent units (TEUs). TEU is a measurement that quantifies the size of a shipping container and is approximately a twenty foot long container with eight and a half foot or nine and half foot high height and a eight foot width. After the expansion, it is expected that a vessel of 1200 feet long, 150 feet wide with a draft of 50 feet and capable of hauling 12,000 TEU will be able to navigate the canal. Some vessels may even be larger and haul a maximum of 18,000 TEUs (Mitchell 2011).

Some studies focused on the economic impact of the canal expansion based on the cost reduction in the transportation costs from the Eastern Coast of the United States to Asian countries and vice versa. We also expect to see cost reduction effect of the expansion for trade from Western Coast of the United States to Europe and Africa. The impacts of the canal expansion are expected to differ by geographic region and by type of the product traded (US Maritime Administration 2013). Panama Canal expansion is expected to reduce costs of transportation and will affect Eastern Coastal and East Coast Inland, Gulf Coast & Lower Mississippi Valley (US Maritime Administration 2013). For example, Texas and Louisiana ports, located in the Gulf category of this study, export 17% of the total US exports valued at $249 billion (Harrison and Trevino 2013).

A recent study by Schneider (2015) indicates that an all-water route between Northeast Asia and the US Gulf ports served by larger bulk vessels could result in a cost reduction of up to $0.35 per bushel for exported soybeans, equivalent of a 13% transportation costs reduction. Schneider (2015) estimated that grain transported to Asia from the US Midwest and Great Plains would cost about fifty-dollars per ton in the larger bulk carriers, or five dollars less per ton than in the Panamax vessel, equivalent to a 10% decrease in transportation costs. This study differs from the previous studies by incorporating the cost reduction expectations into a trade model to analyze the impact of the canal expansion on the bilateral dairy trade. We assume cost reductions are approximately 15%. Although this paper focuses on the dairy trade, this model can also be used for the commodities other than dairy.

The transports through Panama Canal are important for dairy exports in the United States. For example, West Coast states have exported dry milk to Africa and to Europe, respectively, averaged 21 and 1.8 TMT in 2010-2014, which accounts for 9% of total dry milk exports from the West Coast districts. East Coast districts and Gulf Coast, respectively, have exported 33% and 15% of their total dry milk exports to East Asia and South East Asia regions in the same period. Butter exports have followed a different route, but the Panama Canal is still critical for the West Coast custom districts. Average trade quantities from 2010–2014 show that exports from West Coast districts to Africa and Europe account for 65.5% of their total butter exports. However, only 15.7% of the exports from the East Coast districts and very limited exports from Gulf Coast districts go through the Panama Canal.

The model in this study explores bilateral trade flows among the system of top dairy net exporting and importing regions. We focus our attention on the effect of the 15% cost reduction on the exports of the three dairy producing regions of the United States.

Modeling the Effects of the Panama Canal Expansion

Regions

The model includes nine regions—five are net exporting regions (Europe, Oceania, US West Coast, US East Coast and US Gulf Coast) and four are net importing regions (Africa, South East Asia, East Asia, and North America). The United States has been divided into three regions, which are defined by the US Foreign Agriculture Service as custom ports locations for dairy exports. This division allows a better understanding of the regional effects of the US dairy industry because the US West Coast states and other dairy products exporting states are different in terms of industry demographics. The other regions include specific countries of the continents. A breakdown of the regions is given in Appendix Table A2.

Data

The annual export data cover period 2010–2014. The import demand quantities of US and importing regions are collected from Commodity Trade Statistics Data—United Nations (UN-Comtrade 2015). Supply quantities are collected from Food and Agriculture Organization of the United Nations – Statistics Division (FAOSTAT 2015). Shipping costs are collected online from the World Freight Rates for bilateral trade (World Freight Rates 2015).

Prices used in the study are region-specific for both supply and demand. The five-year average price for butter for the three regions are sourced from Agricultural Marketing Services (USDA–AMS 2014). Ad valorem tariffs are collected from Data Bank of World Bank (The World Bank 2015). Demand and supply elasticities for dry milk and butter for each country are sourced from FAPRI – Elasticity Database (FAPRI 2015). Regional elasticities are collected from the USDA Dairy Report (USDA 2004).

The price elasticities are sourced from FAPRI as well as previous studies in milk product for each region. Since there are no studies explicitly covering the regions included in this study, we calibrated elasticities of the important countries in these regions based on the technique of Paris et al. (2011). Price elasticities of supply for milk products generally vary from 1–1.5%, and import regions have supply elasticities just above 1% while export regions have supply elasticities around 1.5%. The price elasticity demand for milk products ranges from -0.2% to -0.5% where exporter countries have more elastic demand elasticity.

Model

Spatial equilibrium model (SEM) is one of the common frameworks developed by Samuelson (1952) and Takayama and Judge (1971). The model determines bilateral trade flows among the regions. The conceptual model is derived following Devadoss (2013). The model includes four aggregated import destinations, five regions of which three are US regions, i ,j = 1,…,9.

Trade destinations are Africa, East Asia, Europe, and South East Asia; and US regions are West Coast States, East Coast and Great Lakes States, and Gulf Coast States. Ad valorem tariff rates and transportation costs are modelled based on Devadoss and Ridley (2014), Devadoss and Aguiar (2006), and Devadoss et al. (2005). We can represent region specific supply and demand functions via the following: inverted demand function for j-th region and supply functions for j-th country':

$$(1)\ p_j^d = a_j - d_j x_j^d, \qquad j = 1, \dots ,9$$

$$(2)\ p_j^s = b_j + s_j x_j^s, \quad j = 1, \dots ,9$$

where a_j, d_j, and s_j are positive coefficients, b_j is also a coefficient, but it may be either positive and negative, p_j^d is regional demand price, and x_j^d is quantity demanded in the *j*-th country, p_j^s is regional supply price, and x_j^s is quantity supplied in the *j*-th country.

The quantities x_j^d and x_i^s must be determined as part of the solution together with the trade flows x_{ij}. We assume the availability of information concerning realized trade flows, x_{ij}, and – as a consequence – knowledge of total quantities demanded, x_j^d , and supplied, x_i^s, in each country.

The algebraic framework of the SEM based on the above demand and supply equations is given below (Devadoss 2013). The objective function in the SEM is to maximize the net social monetary gain function subject to a set of linear constraints. To be able to include ad valorem tariff rates in the optimization model, the net social monetary gain function is used instead of net social welfare function (Ridley and Devadoss 2014; Devadoss 2006). The objective function is constructed by the countries' total revenues, total production costs, transportation costs, and the social loss from import tariffs.

$$(3)\ Max\ \sum_{i=1}^{n}(b_i + s_i x_i^s)x_i^s - \sum_{j=1}^{n}\left(a_j - d_j x_j^d\right)x_j^d - \sum_{i,j} x_{ij}\, t_{ij} - \sum_{i,j} x_{ij}\left(p_j^d - p_i^s\right) + \sum_{i,j} x_{ij}\,(p_j^d \frac{1}{(1+\delta_{ij})} - p_i^s)$$

where x_{ij} is the quantity exported from region *i* to *j*, t_{ij} is per unit transport cost from region *i* to *j*, δ_{ij} is an ad valorem import tariff imposed by region *j* on imports from region *i*.

The maximization problem sets the following constraints on the total shipments from a region. Total quantity shipped from region i to region j has to be larger than quantity demanded domestically:

$$(4)\ \sum_{j=1}^{n} x_{ij} \geq x_j^d \qquad \forall i$$

Total quantity shipped from region *i* to region *j* has to be smaller than quantity produced domestically:

$$(5)\ \sum_{i=1}^{n} x_{ij} \leq x_i^s \qquad \forall i$$

Demand price of the importing region *j* should not be less than the supply price of exporting region *i*:

$$(6)\ a_j - d_j x_j^d \geq p_i^s \qquad \forall i$$

The regional demand price shouldn't be less than the supply price in the same region:

$$(7)\ b_i + s_i x_i^s \leq p_i^d \qquad \forall i$$

Supply price and demand price being equalized by adjusting with the transportation cost and ad valorem tariffs:

$$(8)\ (1+\delta_{ij})(p_i^s + t_{ij}) \geq p_j^d \qquad \forall ij$$

All the demand, supply and shipments are set to positive values:

$$(9)\ x_i^s, x_j^d, x_{ij} \geq 0 \qquad \forall ij$$

We derived coefficient estimates from elasticity values collected from elasticity databases, which is common for spatial equilibrium models. To be able to estimate coefficients, we included total supply and demand quantities for each region and their average supply and demand prices. Slopes for demand and supply are calculated using the elasticity values (Devadoss 2006). The demand and supply functions are used to find the intercept by substituting slope as a coefficient term. The terms are used to construct inverse demand and supply terms shown in equations (1) and (2).

Impact of Panama Canal Expansion on US Dairy Trade Flows

To determine optimal bilateral trade flows the SEM uses demand and supply coefficients, transportation costs, and ad-valorem tariff rates for each region. First, the model produces the baseline solution for bilateral trade flow at the equilibrium. Second, the model generates solution that includes reduction in the transportation costs corresponding to the proposed impact of the Panama Canal expansion. In the next subsection, both the base and the canal expansion scenarios are described. Next, the simulation results for these scenarios are presented and compared. Last, the impact of the Panama Canal expansion on US dairy trade by regions is discussed given the simulation results.

Scenarios

The base scenario is constructed based on 2010–2014 data. The data include trade volumes, prices, domestic production, ad-valorem tariff rates, and transportation costs. After estimating the base scenario, we use the base scenario as a benchmark to compare the result generated by the equilibrium simulation after Panama Canal expansion. It is expected that the Panama Canal expansion would decrease transportation costs from US Gulf Ports to Northeast Asia by 13% and from the East Coast to East Asia by 10% (US Maritime Administration 2013; Schneider 2015). We also assume the similar transportation cost reduction from the West Coast to Africa and Europe. Based on our assumptions, there is roughly 15% reduction in transportation cost including insurance for the regions which use the Panama Canal for milk products trade.

Simulation Results

The optimization problem is solved using primal approach procedure in the General Algebraic Modelling System (GAMS) (Brooke et al. 2015). Table 5 shows five-year averages (2010 to 2014) of the dry milk shipments in metric tons. The rows demonstrate the export quantity from the exporting regions and the columns show the destination regions. The sum of the rows gives the total supply from each region and the column shows the total demand from that region. Table 5 indicates that Europe has a high demand for dry milk, and it also exports significant (in the order of magnitudes) amount to Africa, South East Asia, and East Asia.

Table 5. Dry milk shipments average (TMT) 2010–2014

		Trade Destination										
		Africa	East Asia	Europe	South East Asia	North America	Oceania	US West Coast	US East Coast	US Gulf Coast	Total Supply [a]	Total Export
Trade Origin	Africa	802	0.3	3	1	0	1	0	0	0	806.7	4.5
	East Asia	2	1034	0.1	3	0.2	0.3	0	0	0	1039.8	5.8
	Europe	489	95	1612	138	8	3	0.4	2	0.2	2347	734.7
	South East Asia	49	44	1	691	2	2	0	0	0	789.5	98.3
	North America	3	1	0.2	3	423	0.1	0	1	18	447.3	24.7
	Oceania	187	622	3	460	22	339	0.2	3	0	1635.3	1295.9
	US West Coast	21	49	2	183	1	1	178	0	0	434.9	257.1
	US East Coast	7	1	1	3	5	3	0	115	0	136.1	20.6
	US Gulf Coast	4	0	0.5	1	192	0	0	0	58	255.5	197.7
	Total Demand [a]	1564.8	1845.5	1621.9	1481.7	653.2	350.4	178.5	120.3	76		

Note. [a] The sum of the columns gives the total supply from each region and the rows shows the total domestic consumption from that region.

Dry Milk

The top dry milk exporters are Oceania and Europe. Oceania's top trade destinations are East Asia, South East Asia, and Africa while Europe's top destinations are Africa, South East Asia, and East Asia, in the order of magnitude. Judging by the dry milk export quantities across US custom districts, the West Coast district is the largest dry milk exporter with the highest exports to South East Asia, followed in the order of magnitudes by exports to East Asia, Africa, and Africa (Table 5). We do not witness much of dry milk exports to East Asia and South East Asia regions from the US East Coast and US Gulf Coast district. A significant amount of dry milk exports to North America originates from the US Gulf Coast.

Table 6 demonstrates simulation results post canal expansion and compares them to those of the base scenario for dry milk. The base line scenario represents a theoretical equilibrium that should exist, given supply, demand, transportation costs, and tariffs. The base line value may differ from the five-year average value, listed in descriptive statistics in Table 6 because at equilibrium, we do not expect to keep all bilateral trade among the regions. Thus, the base line scenario simulation results only have nine bilateral trade flows (Table 6).

The second column shows the simulation results post canal expansion. One of the significant results is that the reduction in the transportation costs due to the canal expansion create an entirely new export flow from the Oceania district to Africa and East Coast to North America, denoted by NA indicating no export in the base simulation result. Specifically, they amount to 24.9 and 24.8 TMT, respectively. Furthermore, exports from Gulf Coast to East Asia and from West Coast to Africa increase by 622% and 59%, respectively (Table 6).

Table 6. Dry milk domestic demand and bilateral trade quantity simulation results (TMT)

Exporter – Importer	Base Simulation	Canal Expansion Scenario	Difference	Percentage Change
Oceania - Africa		24.934	24.934	NA
US East Coast - North America		24.793	24.793	NA
US Gulf Coast – East Asia	34.837	251.563	216.726	622.11%
US West Coast - Africa	299.192	476.147	176.955	59.14%
North America - North America	672.877	700.437	27.56	4.10%
East Asia - South East Asia	341.657	352.752	11.095	3.25%
Oceania - Oceania	345.724	347.271	1.547	0.45%
US East Coast - US East Coast	117.26	117.55	0.29	0.25%
Europe - Europe	2017.016	2019.824	2.808	0.14%
Africa - Africa	684.938	679.081	-5.857	-0.86%
South East Asia - South East Asia	428.901	420.635	-8.266	-1.93%
US Gulf Coast - US Gulf Coast	35.517	34.363	-1.154	-3.25%
US West Coast - US West Coast	134.164	129.661	-4.503	-3.36%
East Asia - East Asia	402.621	380.299	-22.322	-5.54%
Oceania - East Asia	1207.174	1132.912	-74.262	-6.15%
Europe - Africa	170.116	144.788	-25.328	-14.89%
US East Coast - Africa	29.763	2.84	-26.923	-90.46%
US West Coast – East Asia	118.705		-118.705	-100.00%
US Gulf Coast - Africa	142.886		-142.886	-100.00%
US Gulf Coast - North America	53.742		-53.742	-100.00%

Note. NA indicates that the base simulation does not have any export amount. The figures in this table show the simulation results calculated by the authors based on base and canal expansion scenarios.

Figure 3 graphically displays results listed in Table 6, particularly, percentage changes in dry milk shipments in a simulated Panama Canal expansion scenario. The results also indicate that the Canal expansion significantly decreases exports from US Gulf Coast to Africa (-100%) and North America (-100%), US West Coast to East Asia (-100%), US East Coast to Africa (-90%), and Europe to Africa (-15%). This may be attributed to the increased competition caused by the origination of the new exports from Oceania, Gulf Coast and West coast. In fact, after assessing the difference in magnitudes column, the export flow from the West nearly perfectly substitutes those from Europe as well as from the East and Gulf Coasts cumulatively to Africa (totaling 177 TMT, if all three trade flows are added together, just seventeen-thousand MT more of the new export flow from the West Coast to Africa). Table 6 also demonstrates that North America will be able to increase their own domestic sales by 4.1%.

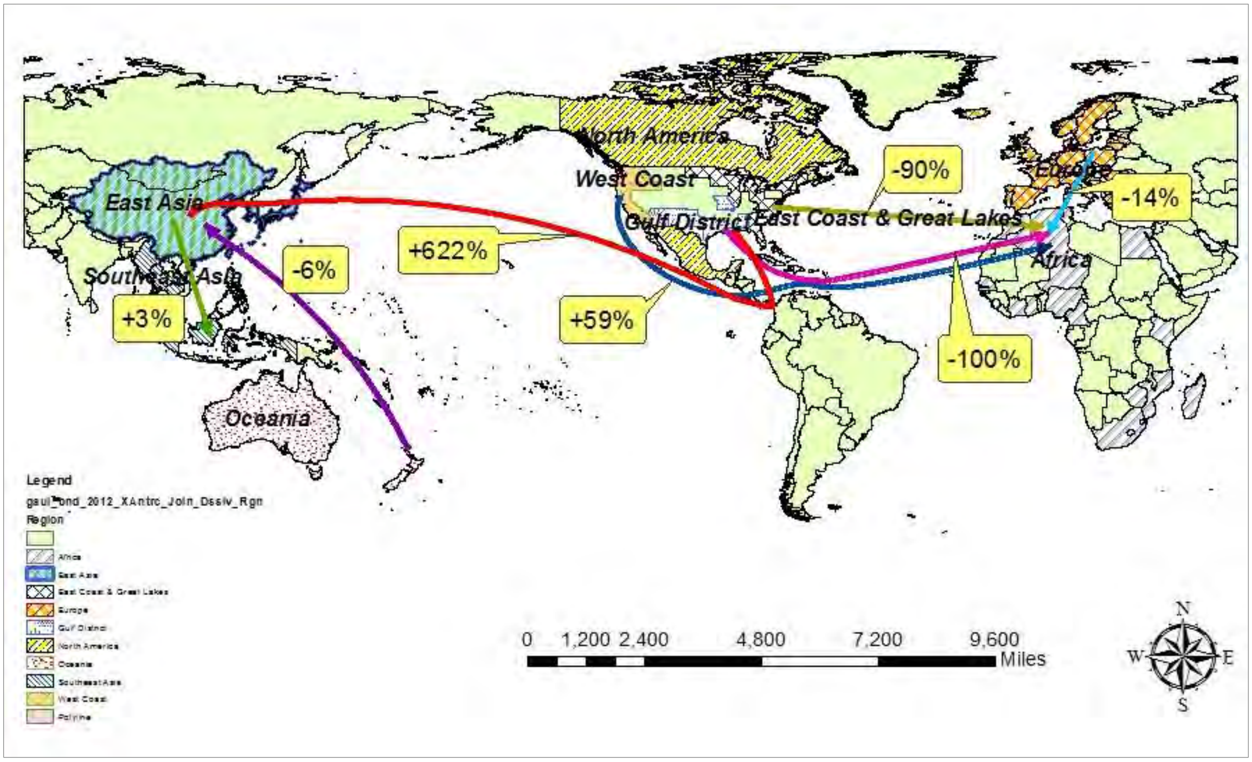

Figure 3. Dry milk domestic bilateral trade percentage changes simulation results
Source: ERSI World Countries 2014[2]

Butter

Table 7 reports the five-year average butter shipments from 2010 to 2014 in metric tons. Similarly, the rows represent the exporting regions and the columns—the destination regions. Assessing total export quantity shipped in the order of magnitudes, it can be seen that Europe is the largest butter supplier in the world with the highest own domestic demand compared to those of the other countries and US regions. Oceania is the second largest and US West Coast is the third largest exporters of butter to all other regions.

The simulation results for the base and the canal expansion scenarios are reported in Table 8. The base line represents a theoretical equilibrium that should exist, given supply, demand, transportation costs, and tariffs. The expansion simulation shows the origination of new export destinations: from Oceania to US West Coast (148 TMT), US East Coast to Africa (121 TMT) and East Asia (45 TMT), and US Gulf Coast to East Asia (122 TMT). It can be seen that trade from the West Coast to Europe as well as Oceania to Africa increase significantly.

On the other hand, Oceania is the largest butter exporter. Oceania's top butter export destinations in the order of magnitudes are South East Asia, Africa, East Asia, and Europe. The top European export destinations are Africa, South East Asia and East Asia, while the top export destinations for the West Coast are Africa, East Asia, and Europe. East Coast district exports in the order of magnitude are to Africa, Europe, and South East Asia.

[2](https://www.arcgis.com/)

Table 7. Butter shipments average (TMT) 2010–2014

Trade Origin	Africa	East Asia	Europe	South East Asia	North America	Oceania	US West Coast	US East Coast	US Gulf Coast	Total Supply [a]	Total Export
	Trade Destination										
Africa	272	0.2	1	2	0	0	0	0	0	274.7	2.5
East Asia	1	308	0.1	0.3	0	0	0	0	0	309.3	1
Europe	18	8	2417	15	1	1	1.2	4	0	2465.1	48.2
South East Asia	1	4	0	130	0.1	0.1	0	0.1	0	135.2	4.9
North America	0	0	0.3	1	137	0.1	0.2	1	1	140.9	4.3
Oceania	69	66	48	87	21	278	0.3	6	0	576.2	298.4
US West Coast	8	5	4	1	1	0.3	406	0	0	425.2	19.5
US East Coast	3	0.1	2	1	0.4	0	0	258	0	263.6	5.7
US Gulf Coast	1	0	0.1	0	6	0	0	0	163	169.7	6.5
Total Demand [a]	372.4	392.5	2472.3	236.7	165.6	279.7	407.4	269.3	164		

Note. [a] The sum of the columns gives the total supply from each region. The rows show the total domestic consumption for each region.

Table 8. Butter domestic demand and bilateral trade quantity simulation results (TMT)

Exporter – Importer	Base Simulation	Canal Expansion Scenario	Difference	Percentage Change
Oceania - US West Coast		147.944	147.944	NA
US East Coast - Africa		120.698	120.698	NA
US East Coast - East Asia		45.256	45.256	NA
US Gulf Coast - East Asia		122.322	122.322	NA
Oceania - Africa	11.267	49.494	38.227	339.28%
US West Coast - Europe	137.882	526.606	388.724	281.93%
East Asia - East Asia	177.41	181.717	4.307	2.43%
South East Asia - South East Asia	110.11	111.368	1.258	1.14%
Africa - Africa	284.058	287.124	3.066	1.08%
US East Coast - US East Coast	164.897	166.211	1.314	0.80%
North America - North America	198.932	198.932	0	0.00%
Oceania - Oceania	290.789	289.991	-0.798	-0.27%
East Asia - South East Asia	75.166	73.677	-1.489	-1.98%
US Gulf Coast - US Gulf Coast	103.017	99.206	-3.811	-3.70%
Europe - Europe	2522.02	2402.19	-119.83	-4.75%
Oceania - East Asia	367.386	195.27	-172.12	-46.85%
US West Coast - US West Coast	273.73	108.781	-164.95	-60.26%
US West Coast - Africa	132.031		-132.03	-100.00%
US East Coast - Europe	173.528		-173.53	-100.00%
US Gulf Coast - Africa	30.28		-30.28	-100.00%
US Gulf Coast - Europe	70.934		-70.934	-100.00%

Note. NA indicates that the base simulation does not have any export amount. The figures in this table show the simulation results calculated by the authors based on base and canal expansion scenarios.

Figure 4 graphically depicts percentage changes for butter shipments in a simulated scenario of Panama Canal expansion as listed in Table 8. The results show that the Canal expansion significantly decreases the exports from US Gulf Coast to Europe (-100.0%) and Africa (-100.0%), US East Coast to Europe (-100.0%) and US West Coast to Africa (-100.0%). Noteworthy is the fact that domestic trade volume contracts significantly for US West Coast (-60%) while imports from Oceania increase.

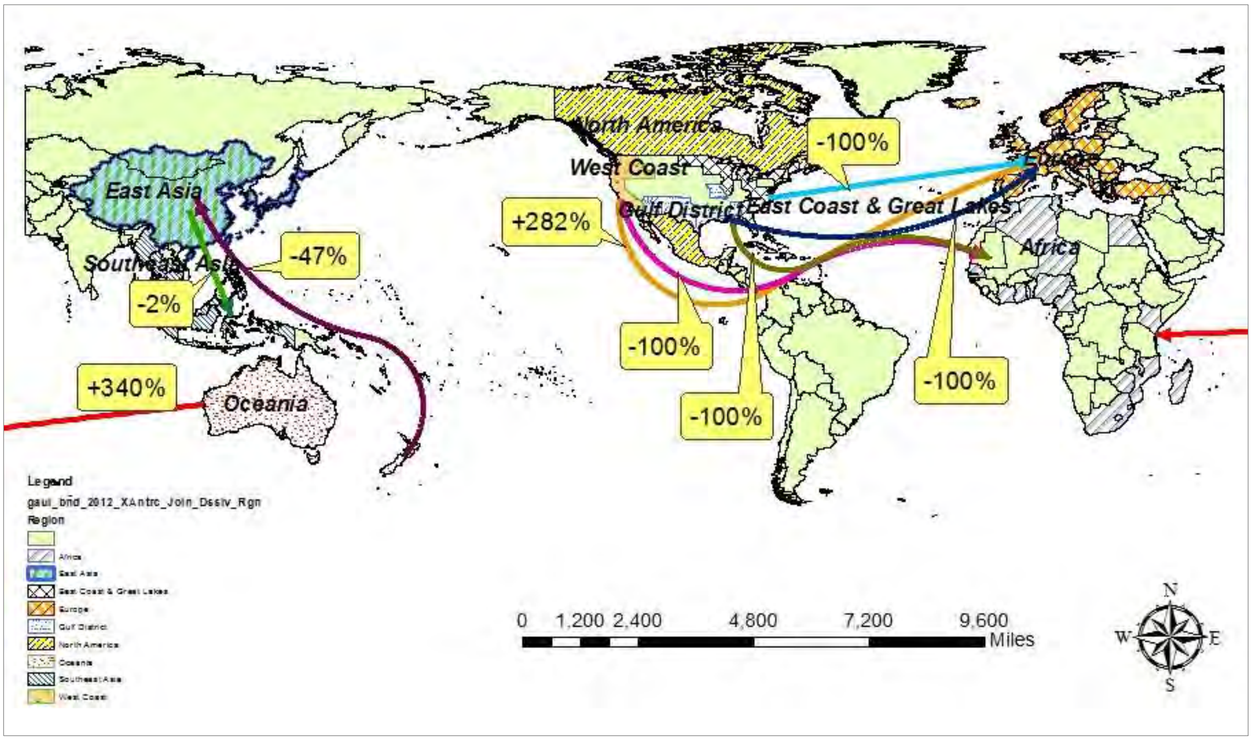

Figure 4. Butter domestic bilateral trade percentage changes simulation results
Source. ERSI World Countries 2014 [3]

Decomposition of Panama Canal Expansion

The Panama Canal Expansion is expected to enhance trade among regions on the Atlantic Ocean and Pacific Ocean. Particularly for food products, the transportation cost accounts for a significant proportion in the total product cost. Therefore, the trade flow of food products will benefit significantly from this expansion.

Although the simulation results show that the canal expansion will increase the trade flow from US West Coast to Africa and Europe; US East Coast to East Asia; and US Gulf Coast to East Asia; the total impact of the expansion varies for each region. It is important to realize the effect of this transportation advancement on each bilateral trade flow. This is precisely the reason this study is relevant and timely.

[3] (https://www.arcgis.com/)

In attempt to summarize the effect of the Panama Canal expansion on the three regions, we perform simulations without decomposing into bilateral trade flows for dry milk and butter. Table 9 shows that canal expansion increases the exports from US West Coast by 13.9% compared to base scenario for dry milk. The US Gulf Coast benefits less from the canal expansion on a relative basis, and, the expansion shows a negative impact in trade flow for the US East Coast compared to the base line scenario.

Table 9. Dry milk exports by US regions (TMT)

	Base Simulation	Canal Expansion Scenario	Percentage Change from the Base
US West Coast	417.9	476.1	13.94%
US East Coast	29.8	27.6	-7.16%
US Gulf Coast	231.5	251.6	8.68%

Note. Values are calculated by authors based on the simulation results.

The canal expansion benefits the butter trade for the US regions (Table 10). The results show that after the cost reduction accomplished by the Panama Canal expansion, the US West Coast increases butter exports by 95.1% compared to that of the base simulation. The US Gulf Coast also increases export volume significantly, 20.9% compared to that under the base scenario. Lastly, for US East Coast districts, the export decrease 4.4% compared to the base simulation. It is important to note that the base simulation results reflect trade volume at the equilibrium when there are no other distortions; therefore, it is not possible to compare the simulated results with actual trade patterns. However, the results are informative in terms of showing us the possible changes in trade flows by the percentage change from the base simulation.

Table 10. Butter exports by US regions (TMT)

	Base Simulation	Canal Expansion Scenario	Percentage Change from the Base
US West Coast	269.9	526.6	95.10%
US East Coast	173.5	166.0	-4.36%
US Gulf Coast	101.2	122.3	20.85%

Note. Values are calculated by authors based on the simulation results.

Conclusions

The Panama Canal is used extensively for dairy exports by the US dairy industry. The expansion of Panama Canal, that is intended to double its capacity in 2016, is expected to increase the tonnage carried by dry bulk and refrigerated cargo, and hence, the competitiveness of dairy exports from the East and Gulf coasts of the US to Asian regions as well as from the West Coast of the US to Africa and Europe.

This study analyzed a dairy trade model for dairy product export quantities from the three dairy producing US regions (i.e. West Coast, Gulf Coast, and East Coast and Great Lakes custom districts). We considered the effect of the Panama Canal expansion on the entire region on a cumulative basis as well as on the bilateral trade flows.

The cumulative effect of the Canal expansion on the dry milk trade is positive for the West Coast and the Gulf Coast, but negative for East Coast and Great Lakes districts. Similar simulation result is obtained for butter trade on all three districts.

When it comes to bilateral trade, the results show that after Panama Canal expansion, increasing trade flows for dry milk from Oceania to Africa, East Coast to North America, Gulf Coast to East Asia and the West Coast to Africa. In case of butter, trade flow increases are expected to originate from the West Coast to Europe, from Gulf Coast to East Asia, Oceania to West Coast and Africa, and from East Coast and Great Lakes to East Asia and Africa. Other bilateral trade flows seem to decrease.

Whereas some bilateral trade flows will increase for some exporter districts and some importer countries, on the cumulative basis, it can be seen that exports of dry milk and butter will increase for West Coast and Gulf Coast districts. However, the cumulative export will decrease for East Coast and Great Lakes districts. West Coast states including: California, Oregon, Washington, and Idaho, will be the biggest beneficiaries of this development in the transportation advancement.

The competitive advantages of the West Coast region aid in harnessing the most benefits from the expansion in trade policies and international demand growth for dairy products. The advantages include favorable geographic location relative to the transportation routes as well as land and resource base that is highly conducive for dairy production. The regions' proximity to international water transportation routes and efficient domestic transportation via regional river systems leading to export terminals translate into lower transportation costs than other regions and allow competitive product pricing.

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Appendix

Table A1. Parameters for demand and supply equations

	Demand Slope	Demand Intercept	Supply Slope	Supply Intercept
Dry Milk				
Africa	74.2012	1444.0218	484.0397	-80.6733
East Asia	65.2066	1861.1935	508.3984	-18.7966
Europe	232.1533	2353.8792	1860.8015	-516.3305
Southeast Asia	128.4974	967.6773	373.9135	-147.9046
North America	24.1467	760.6201	475.5362	-8.9457
Oceania	70.4305	439.3267	2162.2832	-1328.2597
West Coast	46.0023	194.5907	549.3695	-173.9670
Midwest + East Coast	23.9657	149.4915	151.9034	-54.4321
Gulf Coast	17.2208	57.8012	279.0201	-102.2051
Butter				
Africa	18.4656	489.9528	172.9731	-27.4722
East Asia	12.7717	567.2422	159.2646	-18.5551
Europe	338.2392	3528.6514	1658.3251	-542.3171
Southeast Asia	13.3345	208.4897	70.6071	-13.5227
North America	11.6404	218.4751	134.4630	-14.0866
Oceania	44.5502	359.6251	748.1765	-480.9706
West Coast	86.4714	405.7383	463.8838	-170.0907
Midwest + East Coast	58.6218	257.9359	281.1981	-105.4493
Gulf Coast	38.8539	163.1865	177.0453	-67.8674

Note. Values are calculated by authors using elasticities for each region.

Table A2. The country breakdown of the regions

Region	Countries
Europe	United Kingdom, Netherlands, Belgium-Luxembourg, France, Switzerland, Germany, Denmark, Lithuania, Sweden, Spain, Italy, Ireland, Hungary, Latvia, Austria, Croatia, Romania, Norway, Iceland, Greece, Albania, Cyprus, Portugal, Malta, Poland, Estonia, Montenegro, Bulgaria, Turkey, and Kosovo
Oceania	Australia, New Zealand, French Pacific Islands, Micronesia, Samoa, Palau, and Marshall Islands
Africa	Egypt, Algeria, Morocco, Libya, Nigeria, South Africa, Tunisia, Ghana, Mozambique, Djibouti, Swaziland, Cote d'Ivoire, Tanzania, Equatorial Guinea, Senegal, Madagascar, Gambia, the Mayotte, Malawi, Zimbabwe, Sierra Leone, Liberia, Cameroon, Kenya, British Indian Ocean Territory, Niger
South East Asia	Philippines, Indonesia, Vietnam, Malaysia, Thailand, Singapore, Burma, Cambodia, Brunei
East Asia	China, South Korea, Japan, Hong Kong, Taiwan, Mongolia, Macau
North America	Canada and Mexico

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Price Transmission in Global Dairy Markets

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Abstract

The price relationships governing dairy commodity price transmission among the US, Oceania, and EU markets are considered using vector autoregressive (VAR) and vector error correction (VECM) models. Results demonstrate a one-way price relationship for US dry milk powders as price shocks in Oceania and the European Union spread to the United States while US price shocks do not spread into those markets. US prices for cheddar and butter are impacted by price shocks in Oceania and the EU. However, US price shocks also spread into the Oceania market and may reflect potential arbitrage opportunities. Historically thought to be shielded from international prices through low import quotas and high out-of-quota tariffs, these results are the first to empirically demonstrate that US dairy commodity prices are influenced in both the long-run and short-run by international dairy commodity prices.

Keywords: dairy trade, vector error correction, vector autoregression

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Introduction

The global dairy economy now includes more than 175 trading partners and is fast approaching $100 billion dollars in total dairy exports (UN Comtrade Database 2015). Of the $94 billion dollars in dairy products exported in 2014, 87% originated from the big-five dairy exporters including Australia, the European Union, New Zealand, and the United States. A common measure of market concentration, the Herfindahl-Hirschman Index, was estimated for the global dairy export sector to be 0.41 and suggests a high concentration among dairy exporters. Despite such high levels of industry concentration, the prior literature suggests that the law of one price does not hold and that location and currency-adjusted milk and dairy commodity price levels differ considerably across exporting countries. Empirical evidence from Gould and Villarreal (2002) and Carvalho et al. (2015) suggest that United States milk and dairy commodity prices are independent of shocks to international dairy prices.

There are several reasons to revisit the findings of these studies with respect to international and US dairy price relationships. First, the Gould and Villarreal analysis was conducted at a time when the United States had a trade balance in total milk solids equivalent to only 1.2% of the US milk production volume and a negative trade balance with respect to milk fats, Figure 1. [1] However, over the past decade the elimination of export subsidies by World Trade Organization members, specifically the European Union, have helped to make the United States a more competitive export supplier of dairy products to the world. Additionally, financial assistance provided to dairy exporters from USDA's Dairy Export Incentive Program and the farmer-funded Cooperatives Working Together program provided additional support to US exporters (Price 2004). By 2014, the US exported a record 15.4% of the total milk solids volume produced worth as estimated $7.1 billion dollars. Now that the US exports a larger percentage of total domestic production it is appropriate to revisit these international dairy commodity price relationships to determine if exposure to price shocks or the long-run price relationships have changed relative to the findings of previous research.

Second, a majority of the dairy products produced for export in the United States are subject to weighted average milk pricing rules that may mask international milk price shocks (Manchester and Blayney 2001). State or Federal Milk Marketing Orders help to ensure US dairy farmers receive a minimum cash price for their milk through revenue pooling, price discrimination, and end-product price formulas (Newton, Thraen, and Novakovic 2014). These orders determine monthly farm-gate milk prices based on weekly survey prices of cheddar, butter, dry milk powders, and an equalization payment from the revenue pool. The returns from the State or Federal marketing orders differ based on the utilization of milk in a marketing area (Bamba and Maynard 2004; USDA–AMS 2015; CDFA 2015). These equalization payments are generally higher in markets with high utilization of milk for beverage processing compared to areas where a majority of milk production is used to produce lower valued milk powders. For example, in the United States milk price averaged $23.97 per hundredweight during 2014, while the average price paid to dairy farmers delivering milk to Florida milk processors was $28.23 per

[1] Total milk solids include milk fat, protein, and lactose. Trade balance of total solids and milk fats determined using the product composition of all dairy products imported and exported relative to domestic production of all milk solids.

hundredweight and the average paid to California dairy farmers was $22.10 per hundredweight over this same time period (USDA–NASS 2015). As a result, national average US milk prices do not reveal spatial differences in milk prices or the commodity price relationships that defines US end-product milk pricing formulas. As a consequence, Carvalho et al. (2015) omit the intermediate pricing steps and may potentially underestimate the impact of international price shocks on US milk prices defined as: international dairy commodity prices → US commodity prices → US regional milk prices → US national average milk price. Evidence of co-integrating relationships or price transmission between US and international dairy commodity prices may challenge the finding that US milk prices are independent of global dairy markets.

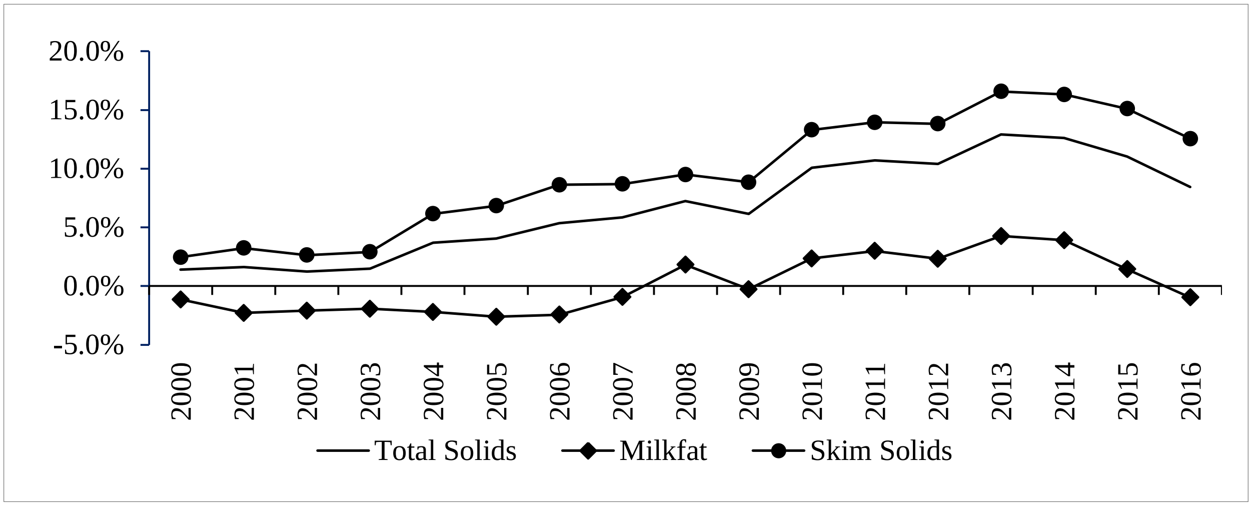

Figure 1. Total dairy product trade balance as a percentage of US milk solids production, 2000 to January 2016.

Empirical literature on price transmission effects in dairy markets have examined the relationship among national average milk prices in international milk markets using vector error correction models (Carvalho et al. 2015); modeled price transmission between farm and retail prices using threshold vector error correction models (Hahn et al. 2015); studied the causal relationships between the prices of milk in selected EU countries (Tluczak 2012); modeled price transmission and asymmetric adjustment in the Spanish dairy sector (Serra and Goodwin 2002); measured correlations between US and international dry milk product prices (Gould and Villarreal 2002); and identified asymmetry in farm-retail price transmission for major dairy products (Kinnucan and Forker 1986; Capps and Sherwell 2005). This article is the first to analyze the global commodity prices relationships for the key dairy commodities governing US milk prices using the vector autoregressive (VAR) and vector error correction models (VECM). The article proceeds with a discussion of global milk price and trade trends. In the following section, descriptive statistics and test results for stationarity and co-integration are presented. Next, based on the stationarity and co-integration test results VAR or VEC models of US and international dairy commodity prices are estimated (e.g. Carvalho et al. 2015, and Hahn et al. 2015). The article concludes by identifying possible causes for observed price effects in global dairy markets.

Global Dairy Trade

Since the early 1990's the United States has been party to eighteen bi-lateral free trade agreements and three multi-lateral trade agreements with direct implications on dairy export opportunities. Yeboah, Shaik, and Agyekum (2015) and Vitaliano (2016) provide a summary of US trade agreements as they pertain to dairy trade. Notable multi-lateral trade agreements include the 1986 to 1994 Uruguay Round, the 1994 North American Free Trade Agreement, and the 2015 Trans Pacific Partnership. Specifically, the Uruguay Round established binding limits on the use of agricultural export subsidies and domestic agricultural support regimes, converted all non-tariff import restrictions on agricultural products to bound tariffs, established science-based disciplines on trade barriers, and created the World Trade Organization (WTO) as an international institution to further liberalize world trade rules.

As a result of these trade agreements, US dairy exports have grown considerably, from $762 million dollars of US dairy products exported in 1994 to $5.3 billion dollars of US dairy products exported in 2015. Primary products exported included nonfat dry milk, cheeses and curds, and whey (USDA–FAS 2015). The recent rise in US dairy product exports has positioned the United States as the third largest dairy exporter in the world behind only the EU and New Zealand. While the historical growth rate may be difficult to maintain, USDA projects the US to grow in its role as a dairy supplier to the rest of the world (USDA 2015). Growing demand in developing countries has driven the expansion in dairy trade. As incomes in developing countries increase, the demand for greater food variety in the form of meat, eggs, milk, and cheeses also increases. These changes in consumption patterns combined with population growth have contributed to large increases in the demand for animal products around the world (FAO 2011). The US has not been the sole beneficiary of increased global demand for dairy products. The share of global dairy exports among the big four exporting countries has grown in recent years. In 2014 Australia, the European Union, New Zealand, and the United States combined to represent nearly 79% of global dairy exports, up from 74% in 2010 (USDA–FAS 2015).

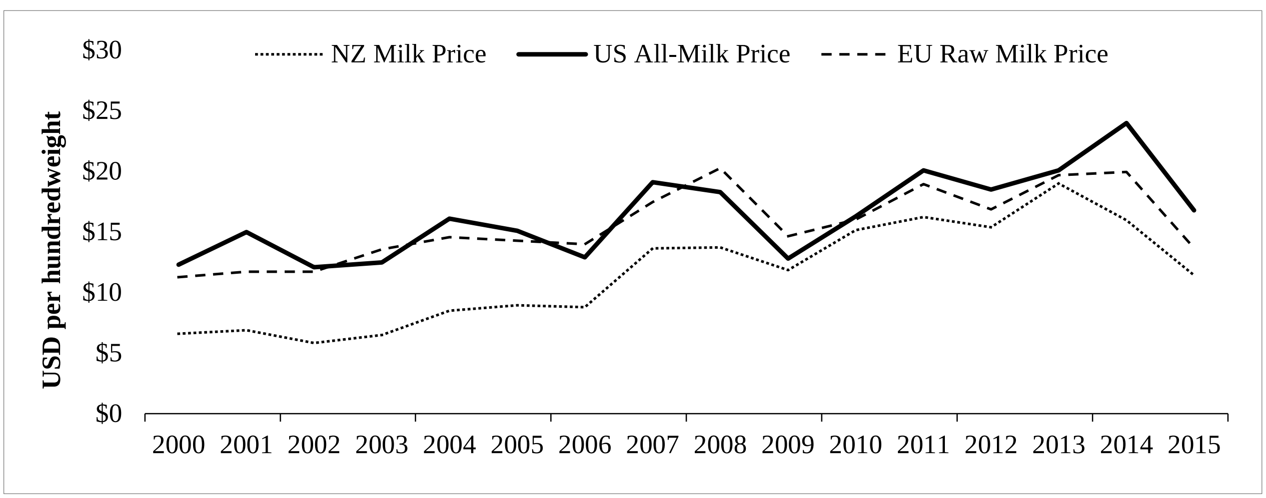

Figure 2. Farmgate milk prices for Europe, New Zealand, and the United States, 2000 to 2015.
Note. New Zealand and EU milk prices adjusted using historical exchange rates and US milk solids and fat content.

Despite the big four exporters representing the majority of world dairy trade, Gould and Villarreal (2002) and Carvalho et al. (2015) found that US milk prices were independent from world prices. Carvalho et al. (2015) did confirm price relationships among several country-level milk price regimes and specifically noted that shocks in the United States or New Zealand spread into other markets. For example, and as evidenced in Figure 2, annual average milk prices in the, New Zealand, and the European Union exhibit high degrees of correlation.[2] Farmgate milk prices in the European Union, New Zealand, and the United States are derivative indices based on the prices of referenced dairy commodities such as cheese, butter, and milk powders (European Commission 2015; USDA AMS 2015). As a result, it is anticipated that the observed correlations in milk prices are driven by both long-run price relationships and short-term price shocks in one market transferring into another. The following sections will review these price dynamics.

US, Oceania, and EU Dairy Commodity Prices

Price data for dairy commodities were collected from a variety of sources. Free on board butter, skim milk powder, whole milk powder, and Oceania cheddar prices were collected from USDA's Dairy Market News on a bi-weekly basis. European weekly average cheddar prices were collected from the United Kingdom's Department for Environment, Food and Rural Affairs.[3] Domestic prices for butter, cheddar, and nonfat dry milk were weekly averages of Chicago Mercantile Exchange (CME) spot market prices and domestic whole milk powder prices were collected from USDA's Dairy Market News. All prices were averaged on a bi-weekly frequency to align with the Oceania and EU prices reported by USDA's Dairy Market News. Table 1 reports the descriptive statistics for the three regions and four dairy commodity prices and Figure 3 shows the historical price relationships.[4] Cross-region correlation was found to be higher in cheddar and milk powders as those products have a higher proportion of disappearance in export channels and higher US tariff rate quota levels (USDA–ERS 2016). Relative to the US cross-region price correlation in butter was found to be 0.56 and 0.50 for Oceania and the European Union, respectively. The lower correlation found for butter is likely a result of the low export volume of US butter relative to domestic consumption and the low TRQs on imported butter into the United States–thereby limiting price exposure from international markets (USDA–ERS 2016; USDA–FAS 2016).

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[2] Milk prices were adjusted based on historical exchange rates and prices based on U.S. milk solids content (butterfat and protein). Correlation coefficients are: U.S.-EU 0.85, EU-NZ 0.77, and U.S.-NZ 0.65.
[3] Exchange rate data was used to convert the weekly European cheddar price into dollar per pound equivalent prices. European cheddar prices are not free on board export prices.
[4] See the Appendix for a correlation matrix of the dairy commodity prices included in this analysis.

Table 1. Descriptive statistics of dairy commodity prices, dollars per metric ton

Variable	Region	Min	Median	Mean	Max
Butter					
	US	1,944	3,283	3,408	6,545
	Oceania	962	2,212	2,655	4,900
	EU	1,050	3,683	3,832	5,723
Cheddar					
	US	2,254	3,392	3,426	5,338
	Oceania	1,550	3,000	3,236	5,500
	EU	2,469	3,682	3,832	5723
NFDM					
	US	1,621	2,232	2,560	4,627
	Oceania	1,188	2,250	2,724	5,562
	EU	1,200	2,350	2,684	5,450
WMP					
	US	2,370	3,120	3,298	4,894
	Oceania	1,212	2,300	2,809	5,600
	EU	1,250	2,650	2,994	5,600

Source. USDA AMS Dairy Market News, European Milk Market Observatory (Exchange Rate Adjusted EU Cheddar Price)

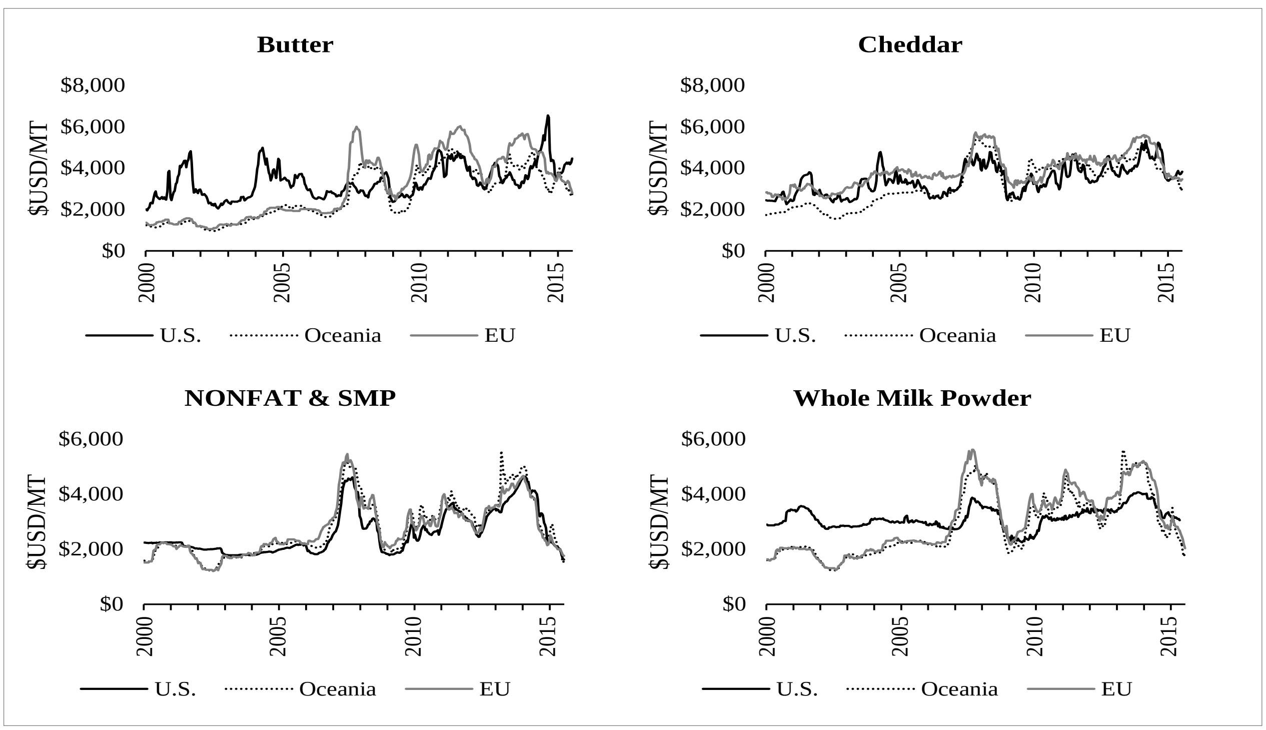

Figure 3. US, Oceania, and EU dairy commodity prices
Source. USDA AMS Dairy Market News, European Milk Market Observatory, Federal Reserve Economic Data

In order to test for price transmission or long-run price effects the first step is to test for stationarity. Non-stationary time series integrated of order one may have at least one co-integrating relationship. The co-integrating relationship allows for a linear combination of the non-stationary time series to be stationary and integrated of order zero. First, to test for stationarity an augmented Dickey-Fuller test and Kwiatkowski–Phillips–Schmidt–Shin test were evaluated for the log of dairy commodity price variables. Dickey-Fuller test statistics revealed that many of dairy commodity prices were trend non-stationary, Table 2. Next, prior to testing for co-integration, several information criteria were evaluated to determine the minimum lag length for evaluation.[5] Then, based on the lag length from the Schwartz (1978) and Hanna and Quinn (1979) metrics, the Johansen (1992) trace test was conducted to identify the number of potential co-integrating relationships. Johansen co-integration test results are present in Table 3.

Table 2. ADF tests of log of price series

Test Value DF_τ	**Butter**	**Cheddar**	**NFDM & SMP**	**WMP**
US	-3.63	-3.68	-2.22	-2.11
Oceania	-2.29	-1.67	-1.99	-1.03
EU	-1.95	-1.17	-1.65	-1.52
Critical Values	1%	5%	10%	
	-3.98	-3.42	-3.13	

Table 3. Johansen co-integration tests for log of NFDM and WMP prices

	Test Statistics		**Critical Value**		
	Lag = 3	Lag = 2	10%	5%	1%
NFDM					
r ≤ 2	6.68	6.25	7.52	9.24	12.97
r ≤ 1	20.25	19.78	17.85	19.96	24.60
r = 0	56.70	63.88	32.00	34.91	41.07
WMP					
r ≤ 2	5.46	4.53	6.50	8.18	11.65
r ≤ 1	12.72	11.47	15.66	17.95	23.52
r = 0	30.99	30.00	28.71	31.52	37.22

For a combination of prices which include at least one trend stationary variable and which do not exhibit a co-integrating relationship, price transmission may be identified using a p-lag vector autoregressive $VAR(p)$ model given by:

$$(1)\quad \mathbf{Y_t} = \mathbf{\Pi_1 Y_{t-1}} + \cdots + \mathbf{\Pi_p Y_{t-p}} + \varepsilon_t$$

where $\mathbf{Y}_t = \left(y_{1t}, y_{2t}, ..., y_{nt}\right)'$ denotes a $(n \times 1)$ vector of time series variables, $\mathbf{\Pi}_i$ are $(n \times n)$ coefficient matrices, and ε_t is an $\left(n \times 1\right)$ zero mean white noise vector process with a time

[5] Akaike information criterion, Hannan-Quinn, and Schwarz criteria were evaluated to determine the optimal lag length. For butter, cheese, and nonfat dry milk the optimal lag length was 2 while the optimal lag length was 1 for whole milk powder. Test statistics available upon request.

invariant covariance matrix $\mathbf{\Sigma}$. For this analysis $\mathbf{Y}_t$ is a (3×1) matrix of first differences of the log of US, Oceania, and European dairy commodity price. Within a $VAR(p)$ model price transmissions across dairy markets are observed in the $\mathbf{\Pi}_i$ coefficient matrix. The sign and statistical significance are indicative of the type of price transmission from one market into another. For example, if no price transmission were present from market 2 to market 1 then π_{12}^i would not be statistically different from zero. Based on the results of the stationarity and co-integration tests a $VAR(p)$ model is appropriate to evaluate price relationships in butter and cheddar.

For a combination of prices that are trend non-stationary and which do exhibit at least one co-integrating relationship, long-run price relationships and price transmission, and the speed of price recovery following a shock are observed using a p-lag vector error correction model given by:

$$(2)\quad \Delta\mathbf{Y_t} = \alpha\beta^T\mathbf{Y_{t-p}} + \mathbf{\Gamma_1}\Delta\mathbf{Y_{t-1}} + \cdots + \mathbf{\Gamma_{p-1}}\Delta\mathbf{Y_{t-p+1}} + \varepsilon_t$$

where Δ represents the first-difference operator, Γ measures the transitory effects similar to the $VAR(p)$ framework, α is the loading matrix and the long run relationships are contained in β. Milk powder prices were stationary when first-differenced and co-integrated. Based on the results of the stationarity and co-integration tests a vector error correction model is appropriate to evaluate price relationships in nonfat dry milk powder and whole milk powder.

Table 4. Vector autoregressive model for log of butter and cheddar prices

	Butter			Cheddar		
Region (lag)	**ΔUS**	**ΔOceania**	**ΔEU**	**ΔUS**	**ΔOceania**	**ΔEU**
ΔUS(1)	0.350***	0.058*	0.014	0.618***	0.081**	0.050
	(0.048)	(0.027)	(0.031)	(0.046)	(0.029)	(0.032)
ΔOceania(1)	0.162[a]	0.246***	0.174**	0.035	0.149**	0.205***
	(0.087)	(0.050)	(0.058)	(0.078)	(0.049)	(0.055)
ΔEU(1)	0.186*	0.184***	0.236***	0.010	0.107*	-0.117*
	(0.076)	(0.044)	(0.050)	(0.069)	(0.043)	(0.049)
ΔUS(2)	-0.219***	-0.022	0.018	-0.358***	-0.025	-0.044
	(0.048)	(0.027)	(0.031)	(0.047)	(0.029)	(0.033)
ΔOceania(2)	-0.068	0.127*	-0.006	0.160*	0.292***	0.113*
	(0.085)	(0.049)	(0.057)	(0.078)	(0.049)	(0.055)
ΔEU(2)	-0.139[a]	0.059	0.151**	0.128[a]	0.034	0.095[a]
	(0.077)	(0.045)	(0.051)	(0.069)	(0.043)	(0.049)
R^2	0.138	0.239	0.172	0.314	0.186	0.075

Note. US reflects nonfat dry milk and Oceania and EU reflect skim milk powder. Lags and Standard errors are in parentheses. ***, **, *, and [a] denote significance level of <1%, 1%, 5% and 10%. Statistically significant price relationships shaded.

Results of the VAR models for butter and cheese indicates that US prices are influenced by prices in both the EU and Oceania, and are the first to empirically demonstrate that US dairy commodity prices are not independent and are instead influenced by international dairy commodity prices. For butter, Oceania and EU price shocks manifest in the following period, while for cheese the price shocks occur in period $t+2$, i.e. four weeks. Additionally, VAR results for butter and cheddar confirm the findings of Carvalho et al. (2015) that price shocks in the US market do spread into other dairy markets. Specifically, price shocks in the United States manifest in the following period— i.e. prices surveyed two weeks later, for Oceania cheddar and butter prices. Price shocks in the United States do not impact EU cheddar or butter prices. Finally, for Oceania and the EU, price shocks in Oceania manifest in both the EU and US over a period of one lag cycle (two weeks), while price shocks in the EU manifest in only the Oceania market.

Table 5. Vector error correction model for log of NFDM and WMP prices

		NFDM			**WMP**	
	ΔUS	**ΔOceania**	**ΔEU**	**ΔUS**	**ΔOceania**	**ΔEU**
Loading Parameters	-0.030**	-0.028	-0.011	-0.060***	-0.011	-0.038*
	(0.011)	(0.014)	(0.014)	(0.015)	(0.021)	(0.017)
	-0.024	-0.014	-0.023			
	(0.021)	(0.028)	(0.026)			
Co-integrating Vector	1.00	0.00	-0.81	1.00	-0.362	-0.094
	0.00	1.00	-1.07			
ΔUS(1)	0.152**	0.034	0.017	0.151**	-0.016	0.092
	(0.049)	(0.064)	(0.061)	(0.051)	(0.071)	(0.056)
ΔOceania(1)	0.232***	0.244***	0.234***	0.023	0.179***	0.202***
	(0.041)	(0.054)	(0.051)	(0.036)	(0.051)	(0.040)
ΔEU(1)	0.024	0.229***	0.300***	0.146**	0.451***	0.229***
	(0.045)	(0.058)	(0.055)	(0.045)	(0.064)	(0.051)
ΔUS(2)	0.149**	-0.033	0.002			
	(0.046)	(0.060)	(0.057)			
ΔOceania(2)	-0.014	0.090	0.061			
	(0.043)	(0.056)	(0.054)			
ΔEU(2)	0.102*	-0.011	-0.070			
	(0.046)	(0.059)	(0.057)			
Constant	0.030	-0.118***	0.030	0.272***	0.049	0.172*
	(0.024)	(0.032)	(0.030)	(0.067)	(0.071)	(0.075)

Note. US reflects nonfat dry milk and Oceania and EU reflect skim milk powder. Lags and Standard errors are in parentheses. ***, **, *, and [a] denote significance level of <1%, 1%, 5% and 10%. Statistically significant price relationships shaded.

For milk powders the results of the VEC models suggest similar pricing dynamics in that US nonfat dry milk prices are influenced by Oceania and EU skim milk powder prices, while US whole milk powder prices are influenced by EU whole milk powder prices. The long run effects indicate that a 1% decline in EU skim milk powder prices would be associated with an eight-tenths of 1% decline in US nonfat dry milk prices and an even larger decrease in the Oceania skim milk powder price. For whole milk powder the co-integrating vector suggests that a one percent decline in the Oceania price would reduce the US price by slightly more than one-third of one percent. The error correction coefficients for US powder prices measure the speed of adjustment towards the long run equilibrium. The coefficient indicate feedback of 3% in nonfat dry milk and 6% in whole milk powder from a shock in the previous period. Importantly, results of the VEC suggest that price shocks in the US market for nonfat dry milk or whole milk powder do not significantly alter prices in the Oceania or EU markets. Milk powder prices in the EU and Oceania show statistically significant co-movement in prices. Impulse response functions provide a visual overview of the dynamic price patterns associated with a one-time shock in a price series. Figure 4 illustrates the impulse response functions associated with a shock in US cheddar prices.

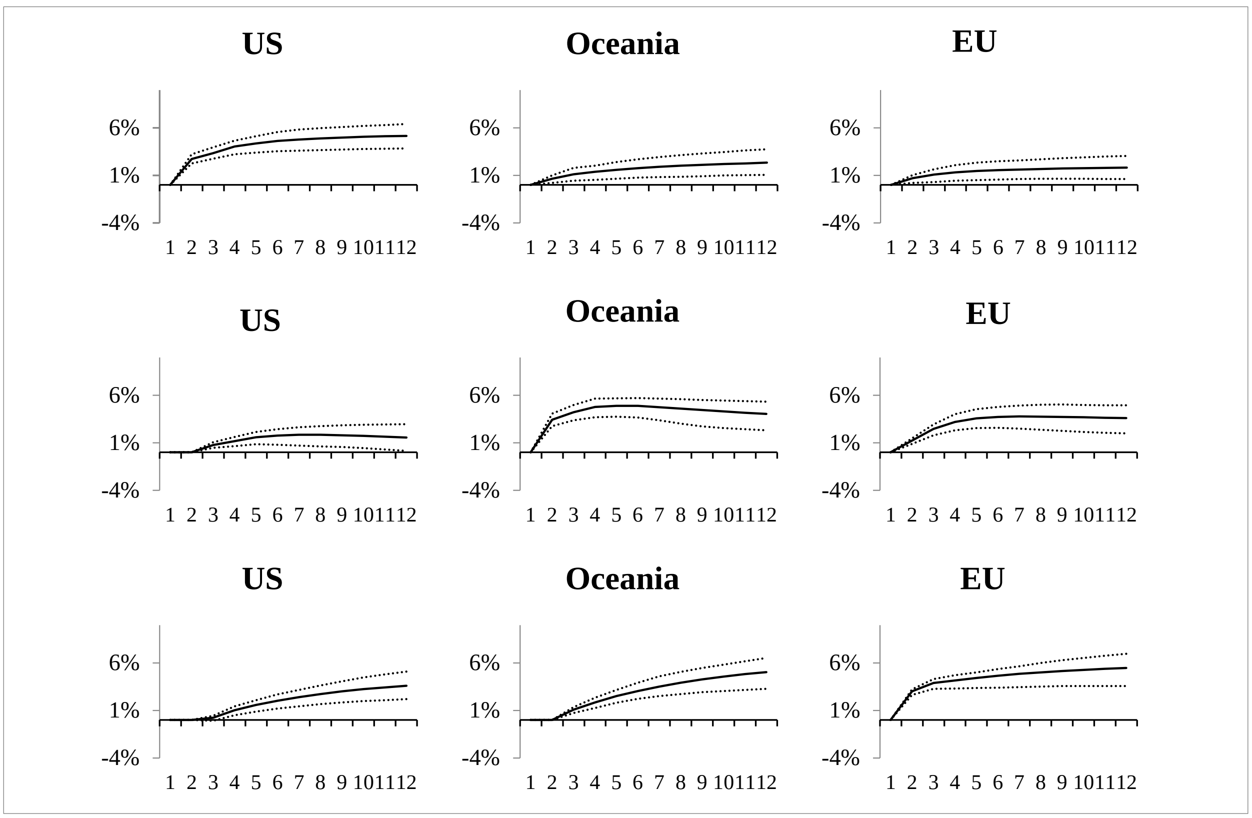

Figure 4. Impulse response function for nonfat dry milk and skim milk powder
Note. X-axis denotes the period following the shock and the y-axis is the magnitude of the impulse response.

Conclusion

A common theme in recent empirical analyses of US and international dairy price relationships was there were no price transmission effects into the United States from international dairy markets (Gould and Villarreal 2002; Carvalho et al. 2015). Results of the VAR and VEC models suggest that US dairy commodity prices for cheddar, butter, and dry milk powders are influenced by the prices of dairy products in international markets. Since dairy commodity prices for cheddar, butter, and dry milk powders are used to directly determine farm-gate milk prices, these results are the first evidence that international dairy prices do have a measurable effect on US farm-gate milk prices. Model results also partially confirm the findings of Carvalho et al. (2015) in that US cheddar and butter prices do spread into other dairy markets while price shocks in US powder prices do not significantly spread into other markets.

The proportion of US powder disappearance in export markets supports the one-way price relationship from international powder markets to the US. USDA commercial disappearance data indicate that 50% of US nonfat dry milk disappearance is in export channels (USDA–ERS 2015).[6] In the United States, surplus milk is used to produce dry milk powders and balance the supply of milk needed for fluid use or cream demand. As a result, dry milk powders are often the lowest priced commodity, and given the large export volume US powder prices follow closely the price of milk powders sold on global dairy markets (USDA–AMS 2015).

While powders represent a large portion of the US dairy export portfolio, less than 10% of US butter and cheese consumption occurs in export markets. Given the small role of US butter and cheese in export channels, the presence of price transmission from US butter and cheddar prices into other dairy markets can likely be explained by several economic factors. First, due to financial and physical shipping constraints, the United States is not positioned to be the primary supplier of cheeses and butter products to the Asian markets. Due to these cost constraints the US market often serves to balance supply and demand for dairy commodities in these markets. Increases in the export volume of US produced butter of cheeses often coincide with short supplies in competing dairy producing regions or increased demand in foreign markets. In such a case, a high tide raises all boats and price shocks in international markets manifest in the United States as global supply and demand conditions find equilibrium.

Second, when US domestic supply and demand conditions lead to higher dairy product prices relative the rest of the world, the US market becomes an attractive export destination for Oceania or EU-produced butters, cheeses, and other products offering similar composition and manufacturing use, i.e. anhydrous milkfat. Arbitrage opportunities are profitable and dairy commodity imports increase when the difference between domestic dairy product prices and the prices for similar products produced in foreign markets exceed transaction costs. Transaction costs of importing dairy products include freight, insurance, and tariff rates. Tariff rates may be applied on a per unit basis (specific rate), as a percentage of the monetary value of the imported item (ad valorem), or both.[7] In general, and not including differences in product characteristics or other transaction costs, for importers of dairy products an arbitrage opportunity is profitable when: $p_w \leq (p_{US} - \tau - c) \times (1+\lambda)^{-1}$, where p_w is the international price, p_{US} is the US price, τ is the in-quota or out-of-quota tariff rate, c is the costs of freight and insurance, and λ is the ad

[6] USDA does not report commercial disappearance of whole milk powder.
[7] Tariff levels are determined whether or not the imported quantity enters the country under in-quota or out-of-quota access. For in-quota access a lower tariff rate is applied, while a higher-tier tariff is applied to any imports in excess of the quota.

valorem tax. An arbitrage opportunity developed in 2015 when the combined effect of the Russian embargo of EU cheese and the lifting of the EU milk quota system led to additional world butter supplies and lower international butter prices. While international butter prices were depressed, tight US supplies of butter—a result of large export volumes in 2014—led to record-high butter prices in the United States. The combined effect of high domestic prices and low world prices led to a surge in US imports of butter and butter substitutes in 2015. Butter imports were significant enough to trigger WTO-authorized butter safeguards imposing additional import tariffs to protect US markets. High US butter prices manifested in internal markets as demand by the US food-service industry for foreign-produced and cheaper butter and butter substitutes increased international butter prices.

These examples highlight how the supply and demand conditions in the global dairy economy effectively link US and international dairy commodity prices. While the price levels are often different, it is the price response to shocks that is transmitted across international markets. These results are particularly important as representatives from twelve countries recently concluded negotiations for the Trans-Pacific Partnership. These results suggest that enhanced dairy trade opportunities as a result of the reduced tariff and non-tariff barriers to trade may further increase the degree of price transmission among global dairy exporters as exporters would be able to more quickly and more frequently take advantage of arbitrage opportunities. For US producers, such an outcome could weaken domestic prices and increase price variability. These price relationships are important to monitor as US end-product milk pricing formulas ensure that US dairy farmer income, profitability, and financial risk exposure will remain tied to both domestic and international dairy markets.

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Appendix

Table A1. Correlation matrix for U.S., EU, and Oceania dairy commodity prices

Table A1. Correlation matrix for U.S., EU, and Oceania dairy commodity prices

	US Butter	US Cheese	US NDMF	US WMP	Oceania Butter	Oceania Cheese	Oceania SMP	Oceania WMP	EU Butter	EU Cheese	EU SMP	EU WMP
US Butter	1.0000											
US Cheese	0.6481	1.0000										
US NFDM	0.2608	0.6924	1.0000									
US WMP	0.4504	0.802	0.9427	1.0000								
Oceania Butter	0.4743	0.6995	0.7199	0.7956	1.0000							
Oceania Cheese	0.4146	0.7817	0.7921	0.8569	0.9476	1.0000						
Oceania SMP	0.253	0.6801	0.927	0.918	0.8228	0.8843	1.0000					
Oceania WMP	0.2106	0.6649	0.8817	0.884	0.8566	0.9085	0.9751	1.0000				
EU Butter	0.4185	0.6948	0.7974	0.8431	0.9573	0.9263	0.8616	0.8732	1.0000			
EU Cheese	0.3469	0.79	0.7511	0.806	0.7893	0.8938	0.8041	0.8337	0.7716	1.0000		
EU SMP	0.2096	0.643	0.9033	0.8838	0.7474	0.8383	0.969	0.9368	0.8135	0.7756	1.0000	
EU WMP	0.2909	0.7069	0.8989	0.9059	0.8792	0.9304	0.9735	0.9709	0.9198	0.8379	0.9637	1.0000

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Potential Impacts of Trans-Pacific Partnership on Japanese Cheese Imports

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Abstract

Japan is a major importer of cheese—second only to the United States in both volume and value. In 2015, the US accounted for 15% of Japan's total volume of imported cheese. If the Trans-Pacific Partnership (TPP), is ratified by Congress, US and other major cheese exporters stand to benefit from duty free or reduced tariff rates. An import demand model is used in estimating Japan's demand for imported cheese. Estimates from this analysis are then used to project Japanese cheese imports in volume and value as a result of TPP. Findings suggest that the own-price elasticities for cheese from the EU–28, US, and the ROW are more sensitive to changes in prices than cheese from Australia. Given a 29.8% reduction in the tariff rate on Japan's fresh cheese imports, Japan is projected to import from the US, New Zealand, and Australia a total of 29.2 million kilograms more cheese. Cheese exporting companies can benefit from the research results that indicate potential export market share changes for competing countries, increases in overall Japanese cheese imports, and price sensitivity of individual country exports of cheese.

Keywords: cheese, demand, imports, trade, TPP, tariff rate

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[1] The views expressed here are those of the author, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Japan is one of the top importers of agricultural products in the world and the third largest dairy importer. Japan is the largest importer of cheese, surpassing Russia after that country's embargo against European cheese imports (Archwamety 2016). Over the last five years, Japan's cheese imports from the US have risen. In 2015, the US accounted for 15% of Japan's total volume of imported cheese, compared to only 7% in 2010. This trend could possibly continue as more regional trade agreements, particularly the Trans-Pacific Partnership (TPP), are put into place to reduce trade barriers. On October 5, 2015, the President of the United States and other country leaders concluded negotiations on TPP, which is yet to be ratified by the US Congress (Calmes 2015). TPP is a trade and investment agreement negotiated by twelve Pacific Rim countries, including the United States and eleven other countries: Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam (Burfisher et al. 2014).

Presently, the basic legislation that governs import trade in Japan is a Customs Tariff Law that sets the bound rates as agreed to in the Uruguay Round (UR) Agreement on Agriculture. Each year, a temporary amendment to that legislation, known as the Temporary Tariff Measures Law, is passed to fix certain tariffs at lower rates. There are several dairy product tariff rates established for which there are no quotas. For cheese and curd, the tariff rate[2] for most of the products imported into the Japanese market falls under the tariff rate of 29.8%. Under the proposed TPP agreement, Japan's tariff rates will be eliminated.

Of the twelve countries currently involved in the TPP trade agreement, three (US, Australia, and New Zealand) are major cheese exporters to Japan and will directly benefit from any reduction in tariffs.[3] The other major cheese exporters are the EU–28 and the rest of the world. In 2000, Japan imported over 205 million kilograms of cheese exceeding $547 million. By 2015, Japan's cheese imports had grown by 21.5% when compared to 2000, while the value almost doubled ($1.187 billion) over the same period. Figure 1 shows Japan's cheese imports by value and source country of origin. Australia is Japan's largest supplier, with EU–28 being a distant second. Growth in export values peaked for EU–28 and New Zealand in 2005, 2008, and 2012. Since 2010, cheese imports from the US climbed steadily until 2015, when export values fell 28% as the US dairy price dropped considerably due to an almost worldwide decline in import demand. The greatest increase in US export values occurred from 2013 to 2014 (see Figure 1).

Market shares of Japan's cheese imports have fluctuated over time (Table 1). From 2000 to 2015, cheese imports from the EU–28 increased by 1% in volume and declined 3% in value. The lack of growth or inability of EU–28 to export more cheese to Japan is primarily due to the

[2] Processed cheese (0406.30), which does not include shredded cheese for pizza, faces a higher tariff of 40%. There is, however, a tariff-rate quota for fresh cheese imported for cheese processing in Japan, with a 0 tariff within the quota.
[3] The Japan-Australia Economic Partnership Agreement entered into force on Jan. 15, 2015. Australia received country-specific tariff-rate quotas related to cheese that offer reduced in-quota tariffs (0 in the case of the TRQ for fresh cheese) for limited quantities (Australian Government, Department of Foreign Affairs and Trade 2016). Because the Japan-Australia Agreement is quite recent, not fully implemented, and limited in scope, we chose to use the TPP-negotiated concessions which apply to Australia as well.

notably tariffs, non-tariff barriers, and unsatisfactory access to the Japanese public procurement market. Similar to EU–28, Australia's market shares also dropped by 8% in volume and 5% in value, over 2000–2015. Australia was not able to meet growing demand of its cheese exports in 2015 due to the country's lower milk production in 2014. Of the five major exporting markets, New Zealand is the only country where market share remained relatively constant during the data period. Cheese exports from the US experienced the greatest growth in market shares. Over the last sixteen years, the US exports of cheese to Japan increased 13% in volume and 12% in value. The US growth in the Japanese market has occurred for many reasons. A few of the reasons are (1) an increase in Japanese consumers demand for quality Western foods; and (2) Japan's strong perception of the US as good food suppliers (Archwamety 2016).

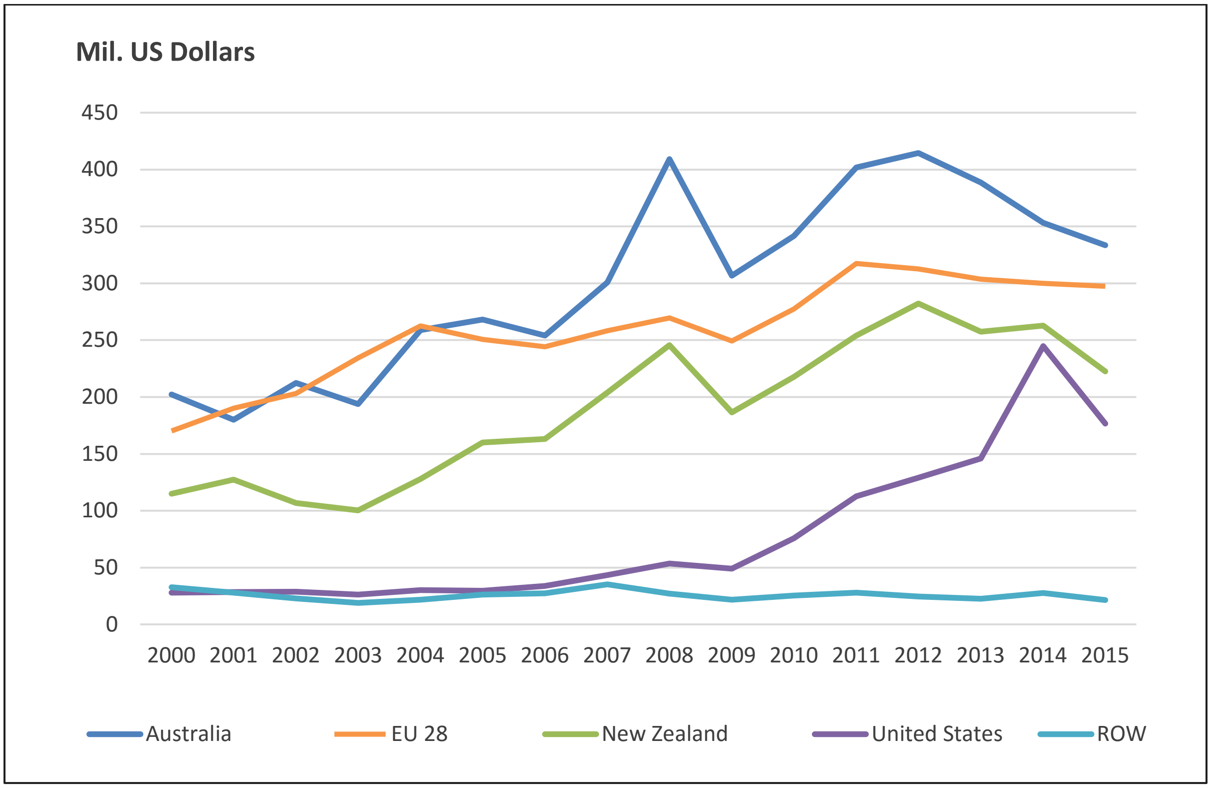

Figure 1. Japanese cheese imports by location and value
Source. World Trade Atlas®

In the study, the impact of tariff reductions in Japan's cheese market are considered. Reductions of 29.8% are assumed and applied to all TPP member countries, particularly the US, Australia, and New Zealand. The objective of this research is to estimate Japan's demand for imported cheese by obtaining estimates of the unconditional elasticities of demand. These elasticities are then used to project Japan's imports in volume and value.

Table 1. Market share of cheese by exporting country and selected years

Japan Imported Cheese		Years 2000	2005	2010	2015
Japan's total cheese imports[1]		205.12	211.62	199.08	249.29
Expenditure on imported cheese[2]		547.77	734.61	938.06	1,029.81
		Market Shares			
EU–28					
	Quantity	0.23	0.24	0.22	0.24
	Value	0.31	0.34	0.30	0.28
Australia					
	Quantity	0.44	0.44	0.43	0.36
	Value	0.37	0.37	0.36	0.32
New Zealand					
	Quantity	0.24	0.26	0.26	0.23
	Value	0.21	0.22	0.23	0.21
United States					
	Quantity	0.02	0.02	0.07	0.15
	Value	0.05	0.04	0.08	0.17
ROW					
	Quantity	0.07	0.04	0.03	0.02
	Value	0.06	0.04	0.03	0.02
Total					
	Quantity	1.00	1.00	1.00	1.00
	Value	1.00	1.00	1.00	1.00

Note. [1]Millions of kilograms. [2]Millions US dollars
Source. Authors' calculation using the World Trade Atlas®.

Rotterdam Import Demand Model

In this study, we estimated an import allocation model and a total impact model. The derived demand for imported cheese is based on the production version of the Rotterdam model. Importing firms in Japan buy cheese from other countries and sell it domestically. Once the cheese has been purchased, production inputs such as fuel and utilities are used to operate the manufactory or storage facilities that house the cheese. Cheese imported from Australia, for example, is considered a separate good within the cheese group, but it is also unique based on its country of origin (Armington 1969). There are some physical differences that exist for various types of imported cheese which could be linked to taste, age, quality, protein and fat content. Along with the physical differences, there are also some perceived differences such as a country's reputation for producing quality products, previous trade relationships, dependability, and political status (Zhou and Novakovic 1996).

The Rotterdam model is a demand system/model that is frequently used to test economic theory. The model works in differentials and all theoretical restrictions are applied directly to the parameters. The production version of the Rotterdam model is a two stage differential approach. The first stage of the differential approach involves firms seeking to obtain a profit-maximizing level of output where marginal cost equals marginal revenue (Washington and Kilmer 2002). Once the profit maximization has been obtained, the second stage of the differential approach is to estimate a system of derived demand equations (Washington and Kilmer 2002). Each derived demand equation is source or country specific.

The production version of the Rotterdam model is used to estimate Japan's import demand for cheese (Theil and Clements, 1978; and Clements and Theil, 1978). Similar to Armington (1969), an assumption made in this study is that cheese from all five major exporting markets are individual goods (e.g., US cheese) in that cheese is assumed differentiated by country of origin. The competitiveness across countries captures how changes in relative prices cause import demand to swing toward or away from different exports. Another assumption is that imported cheese from the five destinations is an intermediate good[4] and is weakly separable from domestic inputs such as fuel, utilities, and intermediate imports.

Following Washington and Kilmer (2002), we can express the demand for an import from a country as a function of the import prices by source and total import expenditures on cheese as:

$$(1)\ \overline{s_{it}}\,\Delta q_{it} = \theta_i\,\Delta Q_t + \sum_{j=1}^{k_1} \pi_{ij}\,\Delta p_{jt} + \sum_{h=1}^{12} \delta_{ih}\, d_h + \varepsilon_{it}.$$

Equation (1) signifies the import allocation model where q_i is the quantity of the *i*th import and p_j is the *j*th import price. Δ represents finite log changes where for any q or p, $\Delta q_{it} = \log\left({q_{it}}/{q_{it-1}}\right)$ and $\Delta p_{it} = \log\left({p_{it}}/{p_{it-1}}\right)$. $\overline{s_{it}} = 0.5(s_{it} + s_{it-1})$, where s_i is the share of the *i*th import in total import cost $\left({p_i q_i}/{\sum_{i=1}^{k_1} p_i q_i}\right)$.

$\Delta Q_{it} = \sum_{i=1}^{k_1} \overline{s_{it}}\Delta q_{it}$ is the Divisia Index. It is a measure of all real expenditures on imported cheese (in total). $\theta_i = \partial(p_i q_i)/\partial(\Sigma_i p_i q_i)$ represents the marginal share of the *i*th import. The conditional import price effect is defined as π_{ij}, also known as the Slutsk Divisia price coefficient. The conditional import price effect measures the effect of the *j*th import price on Japan's cheese imports from country ***i***. Monthly dummy variables (d_h) added to equation (1) measure any seasonal fluctuation in cheese demand, such that δ_{ih} captures any seasonality effects. For estimation purposes, θ_i, π_{ij} and δ_{ih} are assumed to be constant. The error term is ε_{it}.

The adding up, homogeneity, and symmetry condition are respectively imposed as follows: $\sum_i \theta_i = 1$, $\sum_i \pi_{ij} = 0$, and $\sum_i \delta_{ih} = 0$ (adding up); $\sum_j \pi_{ij} = 0$ (homogeneity); $\pi_{ij} = \pi_{ji}$ (symmetry).

[4] More details about intermediate products please see Sanyal and Jones (1982).

The total import expenditures are defined as

$$(2)\quad \Delta Q_t = \gamma \Delta p* + \sum_{j=1}^{k} \pi_j\, \Delta p_j \; + \pi_f\, p_f \; + \pi_u\, p_u \; + \sum_{h=1}^{12} \delta_h\; d_h \; + \varepsilon_t \quad .$$

In equation (2), total expenditures on imported cheese in Japan are a function of resource prices such as fuel and utilities (p_f and p_u), Japan's domestic cheese price (p^*), and individual import prices (p_j). Parameters are γ, π_j, and π_k and are assumed constant for estimation. ε_{it} is the error term. Because of the weak separability of imports and domestic inputs, domestic resource demand will not be modeled within the import allocation system.

In order to derive the unconditional elasticities of demand with respect to fuel and utilities prices, Japan's domestic cheese price, and individual import prices, we substituted equation (2) for the Divisia index term in equation (1). After substitution, we can solve for the following:

$$(3)\;\; \eta_{q\mathrm{p}*} = \frac{\Delta q_i}{\Delta \mathrm{p}*} = \frac{\theta_i}{\overline{s_i}}\gamma\,,$$

$$(4)\;\; \eta_{qp_f} = \frac{\Delta q_i}{\Delta p_f} = \frac{\theta_i}{\overline{s_i}}\pi_f\;,$$

$$(5)\;\; \eta_{qp_u} = \frac{\Delta q_i}{\Delta p_u} = \frac{\theta_i}{\overline{s_i}}\pi_u \;\text{, and}$$

$$(6)\;\; \eta_{qp_j} = \frac{\Delta q_i}{\Delta p_j} = \frac{\theta_i\,\pi_j}{\overline{s_i}} + \frac{\pi_{ij}}{\overline{s_i}}\,.$$

Equation (3) is the percentage change in quantity from the *i* country divided by the percentage change in price. Equations (4 and 5) represent the percentage change in quantity from the *i* country divided by the percentage change in the price of fuel (or utilities). Equation (6) is the percentage change in quantity from country *i* divided by the percentage change in the price from country *j*.

Data and Estimation Results

Monthly observations from 2000 to 2015 are analyzed for Japan's cheese imported, which included import expenditures, quantities, and unit prices obtained from the World Trade Atlas® database. The Harmonized System Codes (HS Code) at the 6-digit level (0406.10 and 0406.20 cheese and curd) are used to collect trade volumes and values for cheese and curd by country of origin. Using the cheese data, price and expenditure elasticities are estimated for each market.

We estimated the five major cheese suppliers imposing homogeneity and symmetry conditions to all. One of the demand equations was dropped from the demand systems to avoid singularity. We dropped the ROW equation for estimation.

To determine if there was an AR(1) problem a likelihood ratio (LR) test was conducted using the maximum likelihood method from Berndt and Savin (1975). The results suggest that AR(1) should not be rejected at the 5% significant level (Table 2). All results that follow have AR(1) imposed.

Table 2. Likelihood ratio test results for AR(1)

Model	Log-Likelihood Value	LR Statistic	P-value
AR(1)	1850.069		
Without AR(1)	1759.408	181.3215	0.000***

Note. Level of statistical significance - ***- 1%.

Table 3 presents the conditional parameter estimates of Japan's import demand for cheese. As shown in Table 3, all own-price coefficients are negative and significant, as expected. The own-price coefficients for imported cheese from the EU–28 (–0.405), the US (–0.085), Australia (–0.168), and the rest of the world (ROW) (–0.433) are significant at the 0.01 significance level, while New Zealand (–0.111) is statistically insignificant. Cross-price parameter estimates indicate that six of the ten cross relationships are positive. These parameter estimates also suggest that EU–28 and Australia (0.228), EU–28 and New Zealand (0.137), EU–28 and US (0.023), Australia and the US (0.036), New Zealand and US (0.028), and Australia and ROW (0.035), cheese products could potentially serve as substitutes within the Japanese market. All six of the above cross-price parameter estimates are statistically significant.

Table 3. Conditional derived demand parameter estimates for Japan's imported cheese

	Exporting Countries				
Japan Imported Cheese	**EU–28**	**Australia**	**New Zealand**	**US.**	**ROW**
EU–28	–0.405***	0.228***	0.137***	0.023*	0.014
	(0.040)	(0.044)	(0.042)	(0.013)	(0.010)
Australia		–0.168***	–0.088	0.036***	–0.035***
		(0.092)	(0.077)	(0.017)	(0.013)
New Zealand			–0.111	0.028*	0.007
			(0.081)	(0.016)	(0.015)
U.S.				–0.085***	0.000
				(0.010)	(0.004)
ROW					–0.433***
					(0.005)

In Table 4, we estimated the impact of the resource prices, import prices, and output prices. Importers rely on fuel and utilities. It is expected that as the prices of fuel and utilities rise, countries will import less cheese given the increase in the cost of domestic transportation and storage facilities. As predicted, the parameter estimate for fuel price (z_i) is positive (1.628), but statistically insignificant, which means that the value of fuel is no different from zero. The parameter estimate for the utilities price was –0.015 and statistically insignificant. Import prices are negative and statistically significant for the EU–28 (–0.590), US (–0.144), and the ROW (–0.125). Australia and New Zealand are statistically insignificant. The output price (0.595) yielded the expected sign, but it was insignificant as well. While output price is statistically insignificant, the positive sign indicates that the imports of intermediary cheese products by Japanese firms give rise to opportunities to add more value to final goods, which are then resold domestically or re-exported to other countries.

Table 4. Parameter estimates of Japan's input price for imported cheese

Input Price Coefficients[1]							
EU–28	**Australia**	**New Zealand**	**U.S.**	**ROW**	**Output Price**	**Fuel**	**Utility**
–0.590***	–0.296	0.231	–0.144***	–0.125***	0.595	1.628	–0.908
(0.136)	(0.228)	(0.220)	(0.050)	(0.049)	(0.858)	(1.304)	(0.832)
R2 = 0.65							

Note. [1]p_f and p_u. Author calculations based on World Trade Atlas®. Asymptotic standard errors are in parentheses. *** implies that the coefficient is significant at the 0.01 level.

Unconditional Price Elasticities

Table 5 displays the estimates of the unconditional price elasticities[5] for imported cheese. Note that all unconditional price elasticities are calculated at the mean. The unconditional own- and cross-price elasticities provide an illustration of the impact of import price changes on cheese imports, holding total imports constant. From a practical and theoretical perspective, Japan will often change how total imports are allocated across the exporting countries as import prices (relative prices) change, but will also change imports due to the effect of prices on total expenditures. Unconditional own-price elasticities show an inverse relationship between source-specific prices and quantities demanded. The own-price elasticities are –1.267, –0.832, –0.006, –1.376, and –1.592 for EU–28, Australia, New Zealand, US, and the ROW cheese, respectively. All of the own-price elasticities estimates are statistically significant except for New Zealand. These own-price elasticities suggest that the demand for cheese imports from the EU–28, the United States, and the ROW tend to be relatively elastic and quite sensitive to changes in price. These findings suggest that a 1% change in price will cause a percentage change in quantity demanded that is greater than 1%. Washington and Kilmer (2002), also found statistical significance among own-price elasticities for the United States, Australia, EU and ROW.

The impact of source-specific price changes can also be captured in unconditional cross-price elasticities as well. A change in the US cheese price could affect total imports such that total volume of cheese imported by Japan can outweigh the impact of relative price changes. Unconditional cross-price elasticities of derived demand for Japanese imported cheese suggest that of the twenty cross-price relationships, six are statistically significant (see Table 5). Four of the six cross-price elasticities are substitutes. A percentage increase in the price of cheese imports from Australia and New Zealand will result in an increase in cheese imports from EU–28 by 0.427 and 0.317%, respectively. Similarly, a percentage increase in the price of cheese imports from New Zealand will increase the volumes of imported cheeses from the US and the ROW by 0.788 and 0.993%, respectively. Other studies that examined Japan's import demand for cheese also support our findings. Washington and Kilmer (2002) findings suggest that Australia and New Zealand cheeses are substitutes for EU cheese in the Japanese market, and that New Zealand cheese is a substitute for the US and ROW cheeses. Using the conditional

[5] The unconditional price elasticity measures the total effect of changes in the price of cheese imports from country j on imports from country i. In contrast to the conditional price elasticity, which measures the effect of relative prices only, the unconditional price elasticity measures the effect of relative price changes and the effect of price changes on total imports.

elasticities of derived demand, findings from Christou et al, (2005) suggest that the EU/the US, the EU/ New Zealand, and ROW/New Zealand cheeses are all substitutes in the Japanese market.

Our findings also show that two of the cross-price relationships are complements. Given a percentage decrease in the price of cheese imports from ROW, results suggest that imports from Australia and the US will increase by 0.156 and 0.159%, respectively. Findings displayed by Washington and Kilmer (2002) for cross-price elasticities among the EU/US and ROW/Australia parallel our study suggesting that these cheeses are complements in the Japanese market. These cheeses from different regions suggest complementary relationships due to product differentiation based on source of location.

Table 5. Unconditional price elasticities for Japan's imported cheese

	Exporting Countries				
Japan Imported Cheese	**EU–28**	**Australia**	**New Zealand**	**U.S.**	**ROW**
EU–28	–1.267***	0.427***	0.317*	0.010	–0.008
	(0.138)	(0.186)	(0.170)	(0.050)	(0.041)
Australia	–0.258	–0.832***	0.104	–0.099	–0.156***
	(0.215)	(0.384)	(0.350)	(0.083)	(0.076)
New Zealand	–0.327	–0.627	–0.006	0.053	–0.011
	(0.209)	(0.379)	(0.381)	(0.085)	(0.075)
U.S.	–0.365	0.085	0.788***	–1.376***	–0.159***
	0.235)	(0.340)	(0.309)	(0.136)	(0.078)
ROW	0.034	–0.171	0.993***	–0.193	–1.592***
	(0.320)	(0.487)	(0.438)	(0.139)	(0.149)

Note. Level of statistical significance - * - 10%, or -***- 1%. Standard errors are in parentheses.
Source. Authors' calculation using the World Trade Atlas® data.

Elimination of Tariff Rates on TPP Countries

The tariff rate imposed by Japan on imported fresh cheese shipped from Australia, New Zealand, and US is 29.8%. For the purpose of this study, no tariff rate reduction is applied to the EU–28 or the ROW, because they are not members of TPP or the percentage of their cheese export to Japan is extremely small in comparison to the selected countries. A complete elimination of tariffs by Japan on cheese imports from TPP partners is assumed, although the TPP concessions by Japan are limited to some major categories, and then qualified by some quantity restrictions and a multi-year implementation period (Office of the United States Trade Representative 2016). Table 6 presents the impact of a zero tariff rate on cheese imports into Japan. The baseline quantities, values, and shares show Australia as the leading country in all of the above categories. New Zealand is the second largest cheese exporter in terms of volume and EU–28 is the second largest exporter from a value perspective.

Given a 29.8% reduction in the tariff rate imposed on fresh cheese from TPP countries, Japanese total cheese imports are projected to increase from 249.2 million kilograms to 267.4 million kilograms, an increase of 7.3%. Most of this increase is driven by the increase in Australia's cheese exports to Japan as illustrated in Table 6. Japan's imports of EU–28 cheese are projected to decrease 17.0% in volume and an increase of 9% in value given a higher average unit price for the previous three years than the unit price recorded in 2015. While EU–28 presently stands as Japan's second largest cheese exporter (28% of market), because it is not a member of the TPP agreement, our projections suggest that once the tariff rates are reduced to zero, the EU–28 will become Japan's third largest cheese exporter in volume. In addition, once TPP is fully implemented, the US is projected to remain Japan's fourth largest cheese market, but will become a strong competitor to the EU–28 for third place.

The difference after the tariff rate reduction results in a total net increase of 18.2 million kilograms and a $198.3 million increase in cheese imports to Japan. The bulk of this expansion is due to the large cheese imports from Australia and New Zealand who are projected to increase their shipments to Japan by 17.1 and 7.7 million kilograms, respectively. Given these increases, Australia's and New Zealand's total values of cheese imported by Japan are projected to increase 31% and 22% from the baseline, respectively. Japanese cheese imports from the EU–28 and the ROW are projected to decline by 10.4 and 0.6 million kilograms, respectively. As a result of favorable dairy prices during 2014, the average cheese price over the past three years (2013–2015) is higher than the average 2015 cheese price, which causes the value of imported cheese from EU–28 to increase $26.7 million once all tariff rates are reduced to zero. Japanese cheese imports from the ROW are projected to fall by $2.2 million. Japan is projected to import 4.4 million kilograms more cheese from the US once the tariff rates are completely eliminated.

Our findings for US cheese differ from the percentage changes found by Burfisher et al. (2014) for a number of reasons. First, the focus of the present study is on fresh cheese, while Burfisher et al. examined both fresh and processed cheeses. Second, the present study estimated Japan's import demand of cheese from Australia, New Zealand, EU–28, US, and ROW using a partial equilibrium model and monthly cheese quantities and values from 2000–2015. All estimated price elasticities were then used to project what the US quantity and value would be once the tariff rates are eliminated. Burfisher et al. used the price elasticity of dairy products for all countries as a proxy for cheese price elasticity and used a general equilibrium model (GTAP) in addition to annual economic data for 2007–2012 and projections for 2012–2025 to determine US projected quantity once the tariff rates are eliminated. These differences are likely to produce distinct results by the two studies.

Table 6. The impact of reductions in Japan's tariff rate on imported cheese.

	Baseline			**Tariff Rate Reduced to Zero**			**Difference after Reduction**		
	Qty (mil. kg)	**Value** (mil. $)	**Share** (%)	**Qty** (mil. kg)	**Value** (mil. $)	**Share** (%)	**Qty** (mil. kg)	**Value** (mil. $)	**Share** (%)
EU–28	61.5	297.5	0.28	51.1	324.2	0.26	–10.4	26.7	0.02
Australia	89.4	333.3	0.32	106.5	435.6	0.35	17.1	102.3	0.03
New Zealand	57.1	222.5	0.21	64.8	272.1	0.22	7.7	49.6	0.01
U.S.	37.0	176.6	0.17	41.4	198.5	0.16	4.4	21.9	–0.01
ROW	4.2	21.5	0.02	3.6	19.4	0.01	–0.6	–2.2	–0.01
Total	249.2	1051.4	1	267.4	1249.8	1	18.2	198.3	0.04

Source. Author calculations based on World Trade Atlas®. Quantity is measured in million kilograms (mil. kg) and value is measured in million U.S. dollars (mil. $).

Summary and Conclusion

In this study, we examined the impact the TPP will have on Japan's cheese import market for five cheese suppliers, EU–28, Australia, New Zealand, the United States, and ROW. Monthly data from 2000 to 2015 were used in estimating an import allocation model and import decision model. In addition to the own-and cross price elasticities, we estimated parameters for the output price, input prices, and resource prices. Our findings indicated that the parameters for output price, input prices, and resource prices were statistically insignificant. All of the own-price elasticities were negative and there are some strong substitutions between New Zealand and other major competitors such as EU–28, the United States and ROW. Our findings also suggest that Australia's and EU–28's cheese products are strong substitutes within the Japanese market.

The US stands to gain from the Trans-Pacific Partnership (TPP) agreement. Cheese exporting companies can benefit from the research results that indicate potential export market share changes for competing countries, increases in overall Japanese cheese imports, and price sensitivity of individual country exports of cheese. However, other TPP countries are major exporters of cheese to Japan. It is unclear as to which TPP country will benefit the most from a reduction in tariff rates. While Australia and New Zealand may benefit more due to proximity, the US has had a long dairy trade history with Japan. Given the recent strength in cheese exports to Japan, the United States could gain considerable benefit from the TPP tariff concessions by Japan.

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Implications of Trans-Pacific Partnership for the US Dairy Industry

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Abstract

The Trans-Pacific Partnership (TPP) agreement would reduce or eliminates tariff and nontariff barriers to trade and increase investment among the parties. Dairy exporting countries in the TPP, including the United States, will compete for market share. This study aims to investigate the possible change in dairy trade flows if the TPP agreement is enacted and the implications for the US dairy industry. An empirical trade simulation model is developed focusing on US dairy trade to analyze the potential impacts.

Keywords: Trans-Pacific Partnership (TPP), US dairy trade, Spatial Equilibrium Model

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Introduction

The Trans-Pacific Partnership (TPP) is an international trade pact that would be more comprehensive than the North American free-trade agreement, covering a greater scope of commerce and markets, comprised of more than 800 million people. The countries involved in the Trans-Pacific Partnership are the United States (US), Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore and Vietnam. The TPP agreement aims to reduce or to eliminate tariff and nontariff barriers to trade and to increase investment among the trading partners (Williams 2013).

The United States exported around 50% of its dairy products to TPP countries in 2014 in value terms (USDA-FAS 2015). Dairy trade was one of the delicate issues during the TPP negotiations (Fergusson et al. 2015). Several factors such as the bilateral trade history, the specific interests of the countries and previous trade agreements played an important role in the negotiation process. US domestic producers and policy makers were concerned about changing the balance in the export arena as it pertains to established markets for US exports. In addition, many stakeholders were interested in determining how the TPP would affect not only dairy exports out of the US, but also imports into the United States. The later interest is not covered in this particular study, but it gives a direction for a future study. This paper develops an empirical trade simulation model focusing on the US dairy trade to analyze the impact of different negotiation outcome scenarios for the TPP on the US dairy industry. The main dairy export destinations for the United States and its competitors from TPP countries are included in the analysis. To be able to foresee the implications of the TPP for US dairy industry we developed a baseline scenario for milk powder trade by the year 2020. Although the TPP aims to eliminate tariff rates for milk powder, we expect that some TPP countries would not eliminate the non-tariff barriers completely. For instance, Canada, Mexico and Japan negotiated to keep some of the tariffs and trade barriers (Suber 2016). Accordingly, we examined the effects of a 50% decrease from existing ad valorem rates which include non-tariff barriers; and an elimination of all tariff rates by the year 2020.

A spatial equilibrium model of the dairy industry is constructed and empirically specified in General Algebraic Modelling System (GAMS) (Samuelson 1952; Takayama and Judge 1971). Bilateral trade among important dairy exporting TPP countries (the United States, Australia, and New Zealand), and major dairy importing TPP countries (Canada, Japan, Malaysia, Mexico, and Vietnam) plus China, the European Union (EU-27) and the rest of the world (ROW) are selected for the analysis.

While this research focuses on the highest traded dairy product, milk powder, the model is applicable to other dairy products as well. Data analysis shows that past bilateral trade values influence current trade values, and future possibilities can be simulated using the latest trade data. It is expected that California and the pacific west coast dairy industry will be the biggest beneficiaries of this partnership because of their locational and infrastructural advantages. However, this study does not cover the possible impact of foreign investment advantages among TPP countries and the provisions on geographical indications due to the limitation of data available and model constraints. Comprehensive and sector-specific economic analyses help quantify the effects of alternative outcomes thereby providing the greatest value to the US dairy industry.

The paper is organized in the following way. We begin with a summary of the previous free trade agreements in the United States and the negotiated TPP agreement items on dairy trade. Next, the trends in dairy trade for TPP countries and the status of the United States within the TPP countries are discussed. Later, model specifications and the data are presented, followed by the demonstration of the simulation results and discussion. We conclude with a direction for future studies.

Trans-Pacific Partnership Negotiation Process and Dairy Trade

The negotiations for the latest free trade agreement, Trans-Pacific Partnership, started on March 5, 2010 in Melbourne, Australia. The United States joined the TPP negotiations in February 2008 (Fergusson et al. 2015). The agreement among eleven nations was finalized on October 5, 2015 in Atlanta, Georgia, United States. Prior to the agreement, the partners that now comprise TPP already made up 41% of US goods exports and 42% of US agricultural exports in 2014 (WITS 2015). The issues requiring political-level decisions focused on market access for key product categories with the highest tariff rates: electrical machinery, dairy, sugar, and textiles and apparel industries. The United States already has free-trade agreements with six of these TPP negotiating countries.

In the TPP context, the United States was also negotiating for improved access for its dairy products the restricted Canadian market, where US dairy exports are subject to 125% MFN tariff rates in 2013 (WITS 2015), and for an opportunity to eliminate some Mexican non-tariff barriers which increase the cost of shipping agricultural commodities (Yeboah et al. 2015).

The United States attempted to negotiate tariff rate reductions for US agricultural exports which would expand US market share. However, some concerns arise from the negative consequences of the TPP negotiations. For example, New Zealand gained an improved position for its dairy industry among TPP countries including the US market (Yeboah et al. 2015). Additionally, New Zealand negotiated for maintaining certain export arrangements for their state controlled enterprises such as Fonterra which controls over 90% of the milk supply in New Zealand. This could substantially affect both US domestic production and dairy exports.

As a result of the negotiations, Canada will keep their supply management program for dairy production. Japan has negotiated full exclusion (no additional access and no tariff reduction) for most dairy products for twenty-five years and sixteen years for grains (Doyle 2012). In the light of these developments, the negotiation process increased the importance of analyzing the price effects of the TPP; the reductions in tariffs; and the reduction in non-tariff barriers for dairy trade.

The number of empirical economic studies evaluating trade and welfare impacts of free trade agreements have increased gradually since the mid-90s when the World Trade Organization's Uruguay Round Agreement on Agriculture and North American Free Trade Agreement (NAFTA) were negotiated (Nicholson and Bishop 2004). Researchers have used various methods to evaluate trade agreements such as the gravity models, general equilibrium models, partial equilibrium supply-demand model, import demand model and VAR models (Yeboah et al. 2015; Zhu and Boskin 2013; Korinek and Melatos 2009; Zhuang et al. 2007; Susanto et al. 2007; Kandogan 2005; Kawasaki 2003; Casario 1996). Some national and international institutes have also developed their own models to evaluate the impact of trade agreements (OECD 1991; Roningen et al. 1991; FAPRI 1993; FAO 1995). However, these studies generally use aggregate data and do not focus on the specific products and/or bilateral trade.

There were studies that focus on the impact of free-trade agreements on the US dairy industry (Langley et al. 2006; OECD 2004; Bouamra-Mechemache and Requillart 2000; Van Bekkum et al. 2000; Cox et al. 1999; Lariviere and Meilke 1999). Several studies from different countries have been published analyzing the implications of the TPP on the dairy industry. For instance, Kuberka (2013) analyzed the effect of TPP on the US dairy trade, Rude and An (2013) on Canadian dairy sector, and Li and Whalley (2014) on Chinese dairy imports (although China is not a partner of TPP). However, these studies focused on certain issues and none analyzed the competition between exporting countries and/or simulated the impact of the TPP on exporting countries comprehensively.

Previous Dairy Trade Agreements for TPP countries and Newly Negotiated TPP Agreement

The United States has free trade agreements with six TPP member countries: Australia, Canada, Chile, Mexico, Peru and Singapore. These agreements have exceptions for tariff reduction or elimination in some goods. One of the earliest free trade agreements of the United States is NAFTA enacted in 1994. NAFTA lifted tariffs on the majority of goods from day one of the agreement for some commodities. Mexico and Canada, two of the largest dairy export destinations for the United States, eliminated all tariff and non-tariff barriers on their agricultural trade, with the exception of dairy.

Australia and New Zealand also have free trade agreements with some of the TPP countries. Particularly, the agreement among ASEAN countries enacted on January 1, 2010, which includes the following countries: Australia, Brunei, Myanmar, Malaysia, New Zealand, Singapore, the Philippines, and Vietnam. This agreement extensively eliminated or reduced the tariff rates between these countries.

The dairy sector was among one of the last subjects in the negotiation process because many countries did not want to reduce its tariff in attempt to protect their industries. On the other hand, New Zealand wished to open the market for its dairy products to the US and Canada. Overall, the US asked Canada and Japan to reduce their tariffs and provide an open trade agreement for its dairy products. In last-minute negotiations, Canada and Japan agreed to increase access to their tightly controlled dairy markets, allowing some American dairy products in, but New Zealand also persuaded the US to accept more of its milk products.

The TPP has given the United States an opportunity to acquire new markets for US dairy producers, however further in the future than desired. Although, New Zealand and Brunei eliminated all tariffs immediately, Japan will eliminate tariffs on cheese in sixteen years and whey in twenty-one years. Japan also established quotas for the imports of US dairy products (whey, butter, milk powder, and evaporated and condensed milk). In Vietnam, the tariffs are going to be eliminated within five years on dairy products. Canada eliminated the tariffs for whey and new duty-free tariff-rate quotas for cheese, fluid milk, butter, milk powders, and other dairy products. Malaysian tariffs have been eliminated on nearly all dairy products along with the tariffs on fluid milk that will be eliminated in fifteen years through quotas. Peru will eliminate tariffs by 2025 for all dairy products. Based on the significant outcomes of the TPP agreements for the dairy industry, this study uses simulations to determine the possible impacts of the latest agreement.

Trends in Dairy Trade among TPP Countries

The dairy product trade of TPP countries has more than quadrupled in the last two decades (WITS 2015). The total dairy product trade value of TPP countries accounts for $30.8 billion in 2014 where the total value is composed of dairy exports by TPP countries, $21.3 billion, and the imports by TPP countries, $9.5 billion (WITS 2015). The dairy trade among TPP countries was $13.2 billion 2014 (Figure 1). In percentage terms total dairy trade of TPP countries increased 108% from 2007 to 2014, whereas, the dairy trade within TPP countries only increased 94% during the same period.

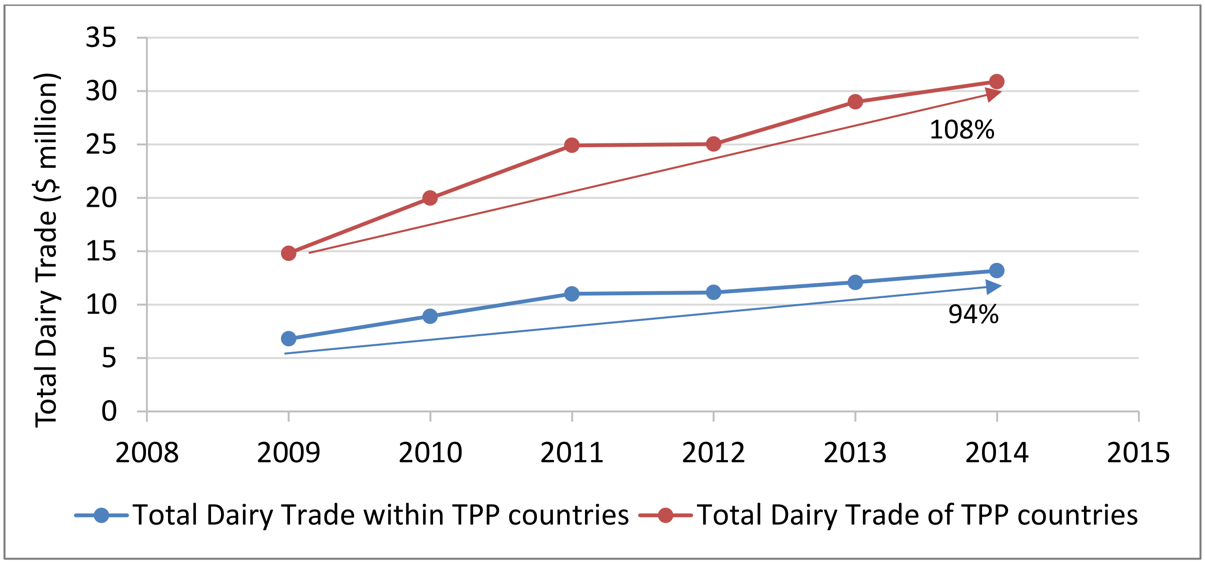

Figure 1. Total Dairy Trade of TPP countries, 2009 – 2014.
Note. Prepared by the authors using the data from WITS (2015).

The TPP partners made up 41% of US goods exports in 2014 (WITS 2015). In 2014, approximately 50% of the United States' dairy exports were destined to TPP countries. The dairy product exports value from the United States to TPP countries was $2.8 billion in 2014 which made up 42% of dairy exports among TPP countries.

Milk powder contributes most to US exports to TPP countries ($1.3 billion), followed by cheese ($0.9 billion), and whey ($0.5 billion) (USDA-FAS 2015). The top US export destinations for dairy, respectively, are: Mexico, Japan, Canada, Vietnam and Malaysia. The other two strong export competitors for US producers in dairy within TPP countries are New Zealand and Australia, with $2.6 billion and $0.9 billion worth exports, respectively (WITS 2015). Thus, these three dairy exporting countries will be expected to compete for the increased market share in the TPP countries (Figure 2). This study models the effects of TPP agreement on the equilibrium that would eventually be reached after the implementation of the recently forged agreement.

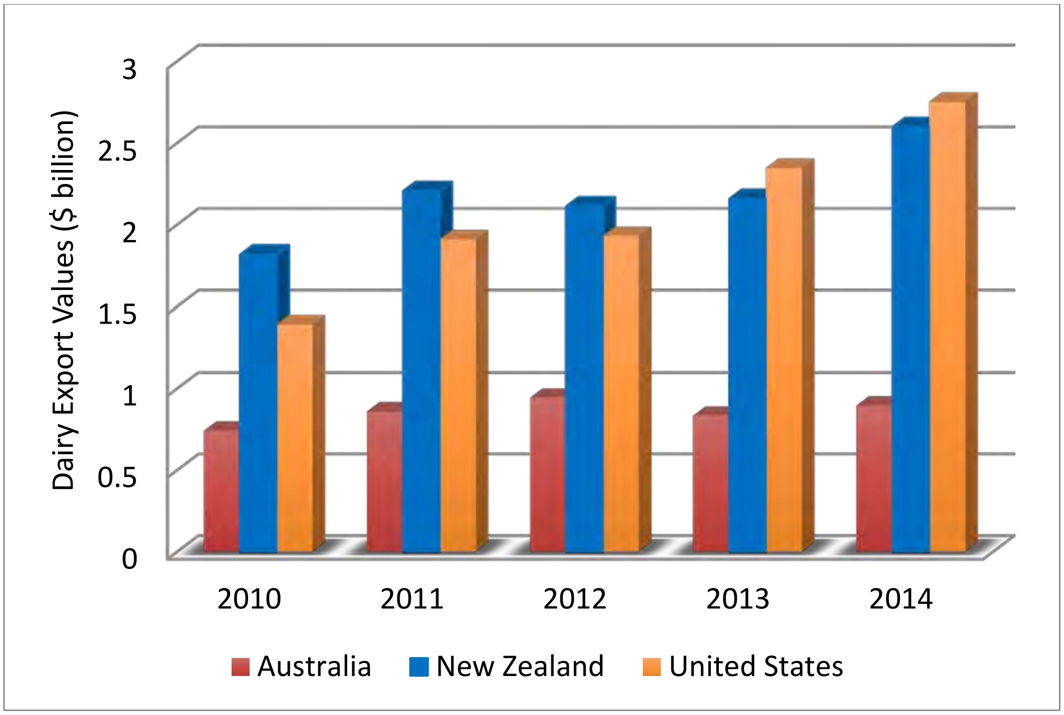

Figure 2. Largest dairy products exporters among TPP countries (Total trade)
Note. Prepared by the authors using the data from WITS (2015).

The domestic demand for milk in the TPP countries is highest in Mexico, Japan, and Canada, and China . When import figures and the production amounts are compared, we see a rapid increase in dairy demand for the emerging markets (i.e. Mexico, Vietnam, China, and Malaysia). In addition, the consumption of dairy products are also robust in Canada and Japan. Figure 3 shows that Mexico is the largest importer followed by Japan, Singapore, Malaysia, Vietnam and Canada (WITS 2015).

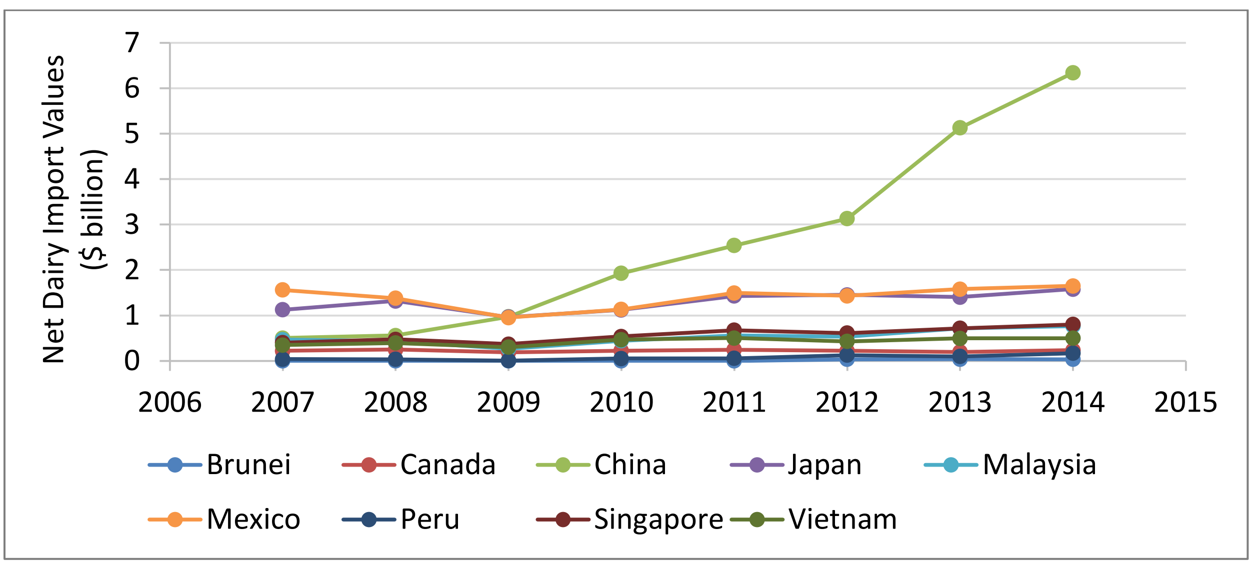

Figure 3. Net Total Dairy Imports among TPP Countries and China
Note. Prepared by the authors using the data from WITS (2015).

Model Specification

Model

A spatial equilibrium model of the dairy industry is constructed and empirically specified in GAMS (Samuelson 1952; Takayama and Judge 1971). Bilateral trade amongst important dairy exporting (the United States, New Zealand, and Australia) and importing (Japan, Malaysia, Mexico, Canada and Vietnam) TPP countries are selected for the analysis. China and Rest of the World are also included into model to compute the overall trade creation, destruction, or diversion impact of TPP agreement on dairy trade. This paper particularly focuses on the highest traded dairy product, milk powder. Following the formulation of spatial equilibrium model, we assume there are *i* export regions and *j* import regions. The demand in region *j* can be written by

$$Q_j = f(P_j, S_j)$$

where Q_j is the quantity demanded by region j, P_j is the price in region j, and S_j is the vector of demand shifters in region *j*. Next, the supply from export region *i* can be written by

$$Y_i = g(P_i)$$

where Y_i is the quantity supplied by export region *i*, and P_i is the export price in region *i*. Following Takayama and Judge, the inverse demand and supply functions, respectively, can be demonstrated as

$$P_j = h(Q_j, S_j)$$

and

$$P_i = k(Y_i).$$

Then, the optimization problem becomes

$$max \sum_{j=1}^{J} \int h(Q_j, S_j) dQ_j - \sum_{i=1}^{I} \int k(Y_i) dY_i - \sum_{j=1}^{J} \sum_{i=1}^{I} T_{ij} X_{ij}$$

$$\sum_{j=1}^{J} X_{ij} \leq Y_i \qquad \forall i = 1, \dots, I$$

$$\sum_{j=1}^{J} X_{ij} \leq Y_i \qquad \forall j = 1, \dots, J$$

$$Y_i,\ Q_i, X_{ij} \geq 0$$

where T_{ij} is the per unit transportation cost from region *i* to region *j*, X_{ij} is the quantity shipped from region *i* to region *j*. The optimal solution of the problem provides the quantity demanded in each import region and quantity supplied in each export region. The solution also allows the optimal flow of product from export regions to import regions.

We also impose an ad valorem tariff by modifying the optimization problem following Spreen (1997). Ad valorem tariff imposed by import region j is represented by AD_j and the price faced by importers in region j becomes

$$P_j = \widetilde{P}_j(1 + AD_j)$$

where $\widetilde{P}_j$ is the per unit price before the duty is paid. To be able to incorporate this relationship, we rewrite the equation as

$$\widetilde{P}_j = \frac{P_j}{1 + AD_j}.$$

To account for the impact of an ad valorem tariff, the first term of the objective function becomes

$$\sum_{j=1}^{J} \frac{P_j}{1 + AD_j} \int h(Q_j, S_j) dQ_j.$$

Data

The model requires five different data sets which include trade flow quantities and prices, import demand and export supply elasticities for the related countries, average ad valorem tariff rates imposed by importing countries, transportation cost from exporting countries to importing countries, and the present and forecasted country demographics for exporting counties as demand shifters. The United States, Australia, New Zealand and the EU-27 are defined as exporters while the others are considered as importers in the model.

The model uses the export and import trade quantities and values for milk powder from 2010-2014 and simulates the impact of the TPP on milk powder trade by analyzing the industry before and after alternative outcome scenarios. The trade values and quantities for milk powder are collected from the World Bank – COMTRADE via World Integrated Trade Solution (WITS 2015). The milk powder data includes the aggregation of six digit HS classification for skim milk powder, sweet milk powder and non-sweet milk powder.

World Integrated Trade Solution software is also used to collect ad valorem import tariff rates transmitted from the UNCTAD Trade Analysis Information System (TRAINS) dataset (WITS, 2015). Import and export elasticities are collected from the Food and Agricultural Policy Research Institute (FAPRI) elasticity database and previous dairy demand and supply studies (FAPRI, 2015). The cost of transportation between two main trade ports for dairy trade is collected using an online tool called freight calculator[1].

Ports selected for export and import regions are: Wellington (New Zealand), Sydney (Australia), Long Beach (United States), Rotterdam (EU-27), Vancouver (Canada), Osaka (Japan), Port

[1] http://worldfreightrates.com/freight

Kelang (Malaysia), Mazatlan (Mexico), Hai Pong (Vietnam), and Qingdao (China). The transportation cost for the rest of the world is assumed to be the average transportation cost from exporting countries to other important ports in Europe, Africa, and Asia. Lastly, population, gross domestic product (GDP), GDP per capita, exchange rate (US/LCU) and time trend are included in the model as demand shifters.

Results

The trade outcomes of three alternative scenarios are analyzed in this study: a) baseline scenario by the year 2020 based on demand shifters; b) a 50% decrease in tariff rates; and, c) the elimination of all tariff rates by the year 2020.

In the baseline scenario, the model captures the trade flow at the equilibrium for the spatial equilibrium model. Table 1 shows the average applied ad valorem tariff rates imposed by net dairy importer TPP countries to net dairy exporter TPP countries in 2013. The method for calculating ad valorem tariffs follows the formulation in TRAINS (WITS 2015). Canada applies the highest ad valorem tariff followed by Mexico, Japan and the Rest of the World (ROW). Table 1 also indicates that Asian countries comparably apply low ad valorem tariff rates on dairy products.

Table 1. Average applied ad valorem tariff rates imposed by net dairy importer TPP countries to net dairy exporter TPP countries, 2013[a]

	Australia	**New Zealand**	**EU-27**	**United States**
Canada	131%	119%	131%	125%
Japan	24%	24%	22%	19%
Malaysia	1%	0%	0%	0%
Mexico[b]	50%	50%	63%	0%
Vietnam	7%	8%	7%	9%
China	10%	6%	10%	10%
ROW	18%	18%	25%	26%

Note. [a] Ad valorem tariff rates are collected from TRAINS dataset in WITS (2015). [b] Mexican ad valorem tariff rate shows 44% on US milk powder import. However, we used 0% tariff rates based on the experts' comments and the latest USDA-FAS publication on the TPP (USDA–FAS 2015).

The results from the spatial equilibrium model for the alternative negotiation outcomes are summarized in Tables 2–4. Simulation results for the 2020 baseline are compared with the actual trade flow quantity and the negotiation simulations are compared with the baseline results. For each alternative negotiation simulation, total import demand, total export supply and bilateral trade flows are reported.

The Impact of the TPP on Importing Countries

Table 2 presents results of the simulation of import demand quantities for selected TPP countries, China and the ROW. The baseline simulation results indicate that the total demand in equilibrium is increasing compared to actual trade flow for all the countries, except for Canada. Vietnam has the highest increase in import demand by 44% in baseline scenario by 2020, followed by China, ROW, Mexico, Japan, and Malaysia. The trade flow from Canada decreases 20% in the baseline scenario. The prospected growth in population and the economy of Vietnam and China made a significant impact on the increasing dairy products demand. The Canadian dairy demand decrease can be attributed to the insignificant population growth in Canada.

Based on the first scenario, if TPP negotiations decrease ad valorem tariff rates by 50% for each TPP country, the import demand of Canada increases more substantially than any other TPP countries by 17%. It is expected that there would be a substantial increase in Canadian import demand because of its protectionist ad valorem tariff rate applied on dairy exporting countries. The increase in demand based on the reduction in ad valorem tariff rates is low but significant for Japan–1.9%, and Vietnam–1.6% compared to the 2020 baseline scenario. Other TPP countries, China and the ROW do not show significant demand change at the baseline scenario.

The elimination of ad valorem tariff rates—the second scenario, also results in increases in the milk powder import demand of TPP countries. Canada shows the highest demand increase by 30% followed by Japan–3.5%, and Vietnam–3.1%. Similar to the previous scenario, we do not find any significant change in milk powder import demand of other TPP countries. We do not expect to see a change in tariff rates in China and the Row. The negotiated TPP agreement shows that Canada keeps their supply management and foreign quotas at 3.3% in dairy market over five years for TPP countries. Thus, by 2020, we do not expect to see any increase in import demands substantialized from the Canadian market.

Table 2. Simulated import demand quantities for selected TPP countries and other significant trade partners, in tons.

	2010–2014 Average	2020 Baseline	Change from Actual	50% Decrease in tariff Rates	Change from Baseline	0% Tariff Rates	Change from Baseline
Canada	5.17	4.33	-19.59%	5.22	17.15%	6.16	29.80%
Japan	30.35	33.40	9.15%	34.04	1.87%	34.61	3.49%
Malaysia	128.22	141.02	9.08%	141.03	0.01%	141.05	0.02%
Mexico	207.81	234.79	11.49%	234.81	0.01%	234.83	0.01%
Vietnam	118.44	209.78	43.54%	213.14	1.58%	216.57	3.14%
China	624.18	987.37	36.78%	987.36	0.00%	987.35	0.00%
ROW	2,942.28	3,599.33	18.25%	3,599.09	-0.01%	3,598.85	-0.01%

Note. [a] The average import demand quantities are calculated by authors using actual COMTRADE milk powder trade (WITS 2015). The quantities show the milk powder import demand from three TPP exporting countries.

The Impact of the TPP on Exporting Countries

The increase in milk powder demand results in an increase in milk powder supply. The simulation results show that the United States has the highest potential to increase actual milk powder supply, by 35%, to meet the increasing demand. This increase is attributed to the change in demand shifters such as population, gross domestic product (GDP), GDP per capita, exchange rate (US/LCU) and time trend for importing countries (Table 3). European Union, New Zealand and Australia, respectively, also increase their supply by 21%, 19% and 3%. Relative to the base scenario, we find that the increase in export supply is highest from Australia–0.11%, followed by the EU-27 and New Zealand–0.09%, and the United States–0.08%. In the same order, the elimination of tariff rates contributes to the export supply of Australia, New Zealand, the EU-27, and the United States, respectively, by 0.23%, 0.19%, 0.17%, and 0.17%.

Table 3. Simulated export supply quantities of net dairy product exporter TPP countries, in tons.

	2010–2014 Average[a]	2020 Baseline	Change from Actual	50% Decrease in Tariff Rates	Change from Baseline	0% Tariff Rates	Change from Baseline
Australia	241.35	247.74	2.58%	248.02	0.11%	248.31	0.23%
New Zealand	1,374.72	1,689.89	18.65%	1,691.48	0.09%	1,693.09	0.19%
EU-27	1,753.83	2,215.93	20.85%	2,217.85	0.09%	2,219.79	0.17%
United States	686.55	1,056.46	35.01%	1,057.34	0.08%	1,058.23	0.17%

Note. [a] The average export supply quantities are calculated by authors using actual COMTRADE milk powder trade (WITS 2015). The quantities show the total milk powder export supply.

The Impact of the TPP on Bilateral Trade

Lastly, we simulated the bilateral trade from milk powder exporting countries (Australia [AUS], New Zealand [NEWZ], the European Union [EU-27], and the United States [US] to importing countries (Canada [CAN], Japan [JAP], Malaysia [MAL], Mexico [MEX], Vietnam [VIET], China [CHI] and the ROW. This simulation shows the optimum trade partnership at equilibrium under the current trade conditions, transportation cost, prices, demand and supply of the countries. The simulation indicates that we have several optimum trade partnerships including from Australia to Japan, Malaysia, and the ROW, from New Zealand to Japan, China and the ROW, from the EU-27 to the ROW, and from the United States to Canada, Mexico, Vietnam and the ROW.

There are several interesting results occurs when we run simulations on the first and second scenarios by changing the tariff rates. First, the results demonstrate that exports from Australia to Japan decline significantly with a 50% decrease in tariff rates in TPP countries, and the decline gets sharper with the elimination of the tariff rates. In turn, the increasing demand of Japan is compensated by the rise in imports from New Zealand. Second, Australia increases her exports to Malaysia and the ROW, and the tariff rate reduction or elimination positively impacts the exports from New Zealand to the ROW. Interestingly, the EU-27 benefits from the trade liberalization among TPP by exporting more to the ROW. The United States benefits highly from the reduction or elimination of tariff rates by exporting more milk powder to Canada and Vietnam. However, the tariff reduction or elimination does not impact exports to Mexico and the results show a reduction in US exports to the ROW.

Table 4. Simulated bilateral trade quantities by among selected TPP countries, in tons.

	2010-2014 Average[a]	2020 Baseline	Change from Actual	50% Decrease in Tariff Rates	Change from Baseline	0% Tariff Rates	Change from Baseline
AUS.CAN	0.10						
AUS.JAP	3.44	14.40	76.11%	14.39	-0.11%	14.34	-0.45%
AUS.MAL	14.05	141.02	90.04%	141.03	0.01%	141.05	0.02%
AUS.MEX	0.84						
AUS.VIET	4.39						
AUS.CHI	24.73						
AUS.ROW	0.19	92.31	99.79%	92.60	0.31%	92.92	0.65%
NEWZ.CAN	0.67						
NEWZ.JAP	44.75	19.00	-135.51%	19.65	3.31%	20.27	6.28%
NEWZ.MAL	3.78						
NEWZ.MEX	7.62						
NEWZ.VIET	17.59						
NEWZ.CHI	20.98	987.37	97.88%	987.36	0.00%	987.35	0.00%
NEWZ.ROW	1.66	683.52	99.76%	684.47	0.14%	685.47	0.28%
EU27.CAN	0.09						
EU27.JAP	522.75						
EU27.MAL	15.53						
EU27.MEX	19.44						
EU27.VIET	71.22						
EU27.CHI	40.84						
EU27.ROW	0.70	2,215.93	99.97%	2,217.85	0.09%	2,219.79	0.17%
US.CAN	4.31	4.33	0.26%	5.22	17.15%	6.16	29.80%
US.JAP	31.96						
US.MAL	7.60						
US.MEX	179.91	234.79	23.37%	234.81	0.01%	234.83	0.01%
US.VIET	25.36	209.78	87.91%	213.14	1.58%	216.57	3.14%
US.CHI	52.23						
US.ROW	0.39	607.57	99.94%	604.17	-0.56%	600.67	-1.15%

Note. [a] The average bilateral trade quantities are calculated by authors using actual COMTRADE milk powder exports (WITS 2015).

Conclusions

Dairy trade was one of the delicate issues in the TPP negotiations (Fergusson et al. 2015). Several factors such as the bilateral trade history, the specific interests of the countries and previous trade agreements played an important role in the negotiation process. US domestic producers and policy makers are concerned about a change in the balance in the exporting arena as it pertains to established US markets. In addition, all parties are interested in realizing how TPP would affect not just dairy exports out of the US, but also imports into the United States. The later interest was not covered in this particular study but gives a significant direction for future studies. This study simulates the possible tariff rate reduction or elimination on milk powder trade after the TPP in in place. The analysis includes main exporting countries, and selected TPP countries, China and the ROW as importers.

According to the finalized TPP negotiations, Canada will continue their domestic supply protection for dairy products with high ad valorem tariffs. This indicates that the United States would benefit little from TPP with regard to dairy product exports to Canada. The simulation results show that the United States would benefit from the TPP by increasing dairy product exports to Vietnam. However, this increase does not offset the decrease in exports to the ROW. Based on these simulations, the United States would have a limited advantage from the TPP agreement on milk powder exports. Australia can benefit by increasing their exports if they can promote more products to the ROW. The EU-27 will also have an advantage from the trade liberalization due to the TPP by exporting more dairy products to the ROW. The results demonstrate that New Zealand, the world's largest dairy exporter, can use this advantage to export more to the ROW and other TPP countries.

The results are sensitive to elasticities, transportation cost, and the structure of the partial equilibrium model. To be able to provide comparable results, future analysis may include sensitivity analysis on transportation cost and elasticities, and different spatial equilibrium models suitable for ad valorem tariffs. However, the analysis suggests that since the United States will not benefit from expanded access to the Canadian market after the TPP agreement is in place. Accordingly, the US should concentrate on opportunities in Vietnam, look to expansion opportunities in the Chinese market and search for new markets for dairy products to avoid potential trade diversion impacts resulting from the TPP agreement.

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Estimating Restrictiveness of SPS Measures for China's Dairy Imports

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Abstract

China has strengthened dairy food safety management with both industrial and trade policies since the melamine incident of 2008. Sanitary and Phytosanitary (SPS) measures constitute the majority of non-tariff measures (NTMs) for China’s dairy imports. Both Trade Restrictiveness Indexes (TRIs) and Overall Trade Restrictiveness Indexes (OTRIs) pertaining to SPS measures are greater than tariff rates for China’s dairy imports. The top ten countries that export dairy to China experienced different levels of market access barriers, depending on whether they export concentrated milk or cream. SPS related measures are essential for China to develop a safe dairy industry. Supplying China with safe and high quality dairy goods is the best method for dairy exporters to overcome barriers of China’s SPS measures.

Keywords: China, dairy, imports, SPS Measures, AVEs, Import Demand Elasticity, TRI, OTRI, MA-OTRI

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Introduction

Dairy food safety has consistently been a key issue for China's dairy industry since the melamine incident of 2008(Qiao et al. 2010; Xiu and Klein 2010; Yu 2012; Jia et al. 2012; Jia et al. 2014). As a result, the Chinese government has regulated the dairy sector by adopting both industrial and trade policies to ensure a sufficient and safe dairy supply. The government continues to strengthen quality and safety inspection of dairy products, regulate dairy market entrance, encourage mergers and acquisitions of dairy firms, and increase investment in research and development (R&D) of dairy sciences. China also supports standard and large scale dairy production with financial assistance in cow breeding, artificial insemination, alfalfa cropping, cow insurance, cow ranch construction, and replacement of milking equipment.

Generally speaking, China has adopted a comparative-advantage-following (CAF) policy in dairy trade to increase dairy imports from the international market. China does not possess a natural endowment advantage in dairy production due to land and water scarcities. China also does not have a comparative advantage in dairy production because currently most dairy farms are small scale and less competitive.

However, to ensure dairy food safety, China has issued many SPS related domestic laws and regulations, which negatively impacts dairy imports. This paper aims to quantify the impact of SPS measures on China's dairy imports by using a trade restrictiveness index model. The next section reviews previous literature regarding methods for assessing trade policies and quantifying SPS measures. Section three describes China's dairy production, consumption, and trade. Section four lists SPS measures for China's dairy imports. Section five explains the suitability of the trade restrictiveness index model and introduces data sources. Section six presents Trade Restrictiveness Indexes (TRIs), Overall Trade Restrictiveness Indexes (OTRIs) and Market Access Overall Trade Restrictiveness Indexes (MA-OTRIs) for China's dairy imports for three critical years. Section seven discusses the results and concludes the paper.

Literature Review

Assessment Methods of Trade Policies

Classical trade theories conclude that free trade is a win-win game for both exporting and importing countries. Free trade enhances specialization, leads to efficient resources allocation, increases production, and provides consumers with more choices and higher levels of consumption utility. Though free trade is beneficial, there are many reasons a country will implement trade policies to restrict exports or imports. For instance, trade policies can protect domestic production, ensure industrial security and food safety, increase environmental quality, support vulnerable groups, raising incomes of interest groups, influence terms of trade, safeguard the health of people, animals and plants, etc. In general, trade policies can be categorized into three types: export promotion, market access barrier, and domestic support.

Quantitative methods for trade policy analysis include inventory measure, price comparison, ex-post econometric regression, and ex-ante simulation (UNCTAD 2013). Each of these methods has its merits and drawbacks. The inventory measure describes coverage ratios and trends of trade policies, without considering character differences of trade measures. Comparing the prices of a traded good can reveal how big the trade cost is between the exporting and importing country. However, price comparison may be inaccurate in estimating restrictiveness of trade polices because other factors, such as distance and preferences, also affect trade costs. The ex-post regression method typically implements a gravity model to estimate the impact of trade measures on trade flows while controlling for variables such as gross domestic product, factors representing comparative advantage, distance, language, cultural barrier, and border. However, the results of this ex-post method might not help to inform future trade policies. The ex-ante simulation method is suitable for assessing the impact of newly implemented policies on trade flows without sufficient data for ex-post analysis. Simulation analysis can be performed in a partial or general equilibrium setting. However, coefficients and elasticities in the ex-ante simulation are typically borrowed from previous work, which are not always available (WTO and UNCTAD 2013).

Tariff liberalization alone has generally proven unsuccessful in providing full market access. NTMs play a key role when considering the degree of free trade as NTMs restrict market access (UNCTAD 2013).NTMs are difficult to quantify because they are specific to particular commodity and can differ between countries. As a result, researchers estimate the ad valorem equivalent (AVE) of non-tariff barriers. However, ad valorem tariff rates and AVEs of NTMs alone do not fully represent the restrictiveness of trade policies directly because import demand elasticities also play a key role in determining trade restrictiveness. A trade barrier will not have a substantial impact on an imported good if the good is a necessity to consumers in an importing country (Kee et al. 2009).

Assessment Methods of SPS Measures

Previous literature explored several ways to assess the impacts of SPS measures on trade. Engler et al. (2012) constructed a stringency index of SPS measures and quality-related standards for Chilean fresh fruit exports. Interviews with export representatives were conducted to obtain information on all SPS measures. Grant et al. (2015) developed a novel data base of SPS treatment and used a product-level gravity model to assess the effect of SPS requirements imposed by importing countries on US exports of nine fresh fruits and vegetables. Rich et al. (2009) established a system dynamics model to examine the feasibility of a proposed SPS certification system under a number of scenarios. Neeliah et al. (2013) used firm-level surveys and in-depth interviews in assessing the relevance of the European Union (EU) SPS measures to the Mauritian food sector. Drogué and DeMaria (2012) built a similarity index of Maximum Residue Levels (MRLs) in assessing the impact of pesticide residues on apple and pear trade between thirty-eight exporting countries and forty importing countries.

Estimation results of the impacts of SPS measures on trade flows differ widely. Crivelli and Groschl (2012) estimated a Heckman selection model at the HS4 disaggregated level and found that SPS measures constitute barriers to agricultural trade consistently to all exporters. However, their results show that conditional on market entry SPS measures contribute to trade positively. Fontagne et al. (2015) implemented the specific trade concerns (STCs) to capture the restrictiveness of product standards. In their findings, SPS concerns not only discourage the presence of exporters in SPS-imposing markets, but also have a negative effect on the intensive margins of trade. Also, larger firms suffer most from these negative effects of SPS measures. Foletti and Shinga (2014) studied the effect of heterogeneity in Maximum Residue Levels (MRLs) regulation on bilateral trade. They concluded that MRL regulatory heterogeneity diminishes trade at the extensive margin, but increases trade at the intensive margin. Ferro et al. (2015) created a standards restrictiveness index on maximum residue levels of pesticides for sixty-one importing countries. Their results suggest that more restrictive standards are associated with a lower probability of observing trade. But once firms enter the market, standards do not impede exports. Xiong and Beghin (2014) disentangled the effects of MRLs on the import demand and foreign exporters' supply. They found that the MRLs jointly enhance the import demand and hinder foreign exporters' supply.

To the authors' knowledge, there are no specific papers that assess the impact of SPS measures on China's dairy imports. Sun et al. (2014) estimated a gravity model to analyze the effect of changing food standards on China's imports of concentrated milk and cream. They conclude that changes in food standards did not impede China's dairy imports. However, changes in food standards is just one form of the SPS measures, and the results of Sun et al. (2014) leave many questions unanswered.

Thus far, the vast majority of previous studies estimated the impacts of SPS measures from the perspective of exporting countries. This paper assesses the effect of SPS measures on dairy imports of just one country, China. Therefore, the methods developed by previous studies are not applicable to this analysis.

Dairy Production, Consumption, and Trade of China

The Importance of China's Dairy Sector

Though milk was rarely consumed in China historically, it has gradually become a significant part of urban Chinese breakfasts. As incomes increase, Chinese consumers' demand for dairy products will continue to grow (Bai et al. 2014).Dairy products have become one of the main sources of calcium and protein for Chinese consumers. As a result, the Chinese central government aims to ensure thirty-six kilograms of dairy consumption per capita by 2020 (The State Council of China 2014). The increase of China's dairy sector will provide Chinese farmers with more opportunities to participate in a potentially more lucrative, high-value business (Huang et al. 2010).

The Melamine Incident and Governmental Solutions

Chinese dairy farms continue to remain small. Backyard dairy farms with less than four cows account for 75.41% of the total farms, but produce only 22.54% of milk in 2012(Chinese Ministry of Agriculture 2013). Laborers working for backyard dairy farms tend to be under-educated and untrained. If labor input increases by 1%, milk production per cow will decrease by 12% in backyard dairy farms (Yu 2012). The low productivity of small dairy farms (5.23 metric tons of milk per cow per year in 2012) causes milk quality and safety problems. Dairy processors in China have strong oligopsony power over small dairy farms. To stabilize profit, some small dairy farms have adulterated their milk products with water and other chemical elements (Dai and Wang 2014). The melamine incident in 2008 was brought about by an absence of quality control and inspection, low level of production standards, a less developed supply chain of the dairy industry, and regulatory failures of milk stations (Xiu and Klein 2010; Sharma and Zhang 2014).

The melamine incident decreased consumer confidence in domestic dairy products. The Chinese government reacted to the melamine incident by shutting down small private milk stations. It attributed the melamine incident to small scale household milk production and encouraged large scale standard dairy production (Zhong et al. 2013). After the melamine incident, the Chinese government put forth marketing management policies that are effective in maintaining dairy participation and herd size. However, the government's post-crisis management policies and production management policies failed to stimulate dairy production (Jia et al. 2012). The Chinese government heavily regulated milk procurement agencies after the melamine incident. Food and drug administration strengthened milk testing, but the principal-agency problems still exist between government agencies and private sectors in China (Jia et al. 2014).

Dairy demand in China increased due to rapid income growth, changes in urban lifestyle, and the development of marketing channels. Multinational dairy firms will play an increasingly important role in China's dairy market (Fuller et al. 2006). Consumer confidence fell after the melamine incident, which gives an advantage to foreign dairy firms in selling dairy goods to China (Cheng et al. 2014).

Dairy Production

During 2000–2007, China's dairy industry had witnessed rapid development with an annual arithmetic growth rate of 23.01%. Raw milk production grew from 8.27million metric tons in 2000 to 35.25 million metric tons in 2007, increasing by 326.24%. In 2013, raw milk production reached 35.31 million metric tons, decreasing by 5.70% from 2012(see Figure 1).

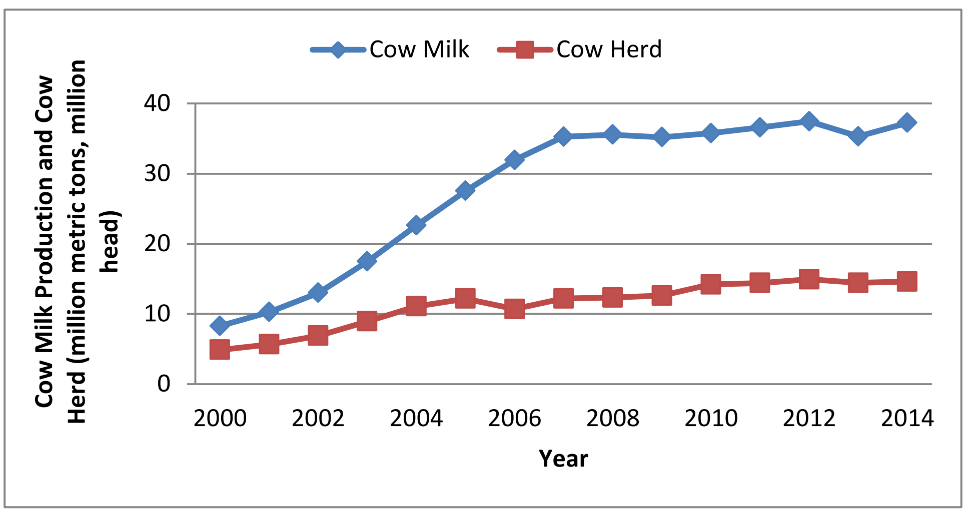

Figure 1. China's cow milk production and herding from 2000–2014.
Source. Ministry of Agriculture (2013) and Li et al. (2015).

After the melamine incident of 2008, dairy production in China slowed down because of less developed feed industry and epidemic diseases. Due to limited land resources, China can't produce enough roughage such as silage corn and alfalfa for cows. The feed conversion rates in dairy farms of different sizes lay between 0.8 and 1.1, which are less than those of developed countries. China's dairy industry also faces threat of epidemic diseases. Foot and mouth disease is frequently reported by dairy farms in northeast and northwest China. Other epidemic diseases such as Brucellosis, Tuberculosis, Virus Diarrhea and Infectious Bovine Rhinotracheitis etc., are also difficult to control.

China's dairy production is mainly concentrated in the Northern provinces, especially Inner Mongolia, Heilongjiang, Hebei, Xinjiang, Shandong and Henan. In 2012, the top ten dairy producing provinces in the north China produced 83.4% of raw milk for the whole country with 82.3% of national cow stocks. China's dairy industry is still in its initial stage of development, and the dairy productivity is quite low. On average, a milking cow in a large scale dairy farm could only produce 6.45 metric tons of milk in 2012, which was much less than developed countries such as the US and the EU (Chinese Ministry of Agriculture 2013).

China is the world's third largest dairy producer after India and the Unites States. In 2012, China processed 25.46 million metric tons of dairy products, including 21.47 million metric tons of fluid and 3.99 million metric tons of solid dairy goods (Chinese Ministry of Agriculture 2013).Though China's dairy processing industry is growing quickly, it still faces challenges: (1) Dairy production and consumption are unequally located in China. Provinces in the south are economically developed and have strong demand for dairy goods, but dairy production of these south provinces is less than that of north provinces. (2)Processing equipment and machines rely on imports. (3) Dairy producers are not active in using new technologies such as membrane filtration sterilization, inflatable packaging, etc. (4) Dairy product mix is not satisfying. The percentage of fluid dairy products continues to increase. On the contrary, the percentage of dry dairy products continues to decrease (Sino-Dutch Dairy Development Centre 2014).

Dairy production such as butter, cheese, milk powder, condensed milk, and whey cannot meet consumption. China has a trade deficit of the dairy products mentioned above. In 2012, imports of butter, cheese, milk powder, condensed milk, and whey amounted to 48.33, 38.81, 572.88, 5.51, and 378.38 thousand metric tons, respectively. Imports of butter, cheese, milk powder, condensed milk, and whey were separately 60.33, 171.86, 143.81, 7.66, and 2643.79 times the amount of exports.

In 2014, mainland China's dairy firms produced 26.52 million metric tons of dairy products, decreasing by 1.71% from the previous year. Fluid dairy production reached 24.01 million metric tons and accounted for 90.54% of total dairy production. The output of dry dairy production was 2.51 million metric tons, which is 4.17% lower than 2013(see Figure 2).

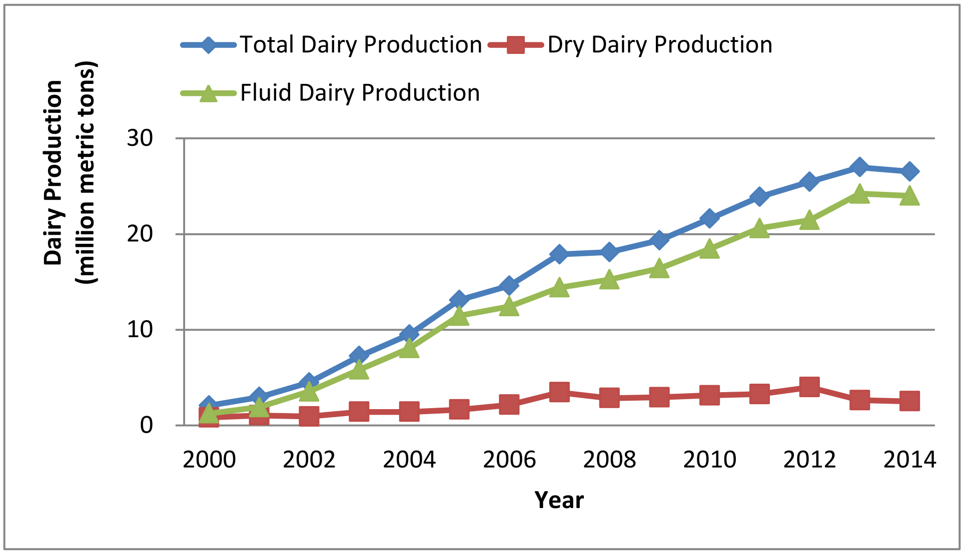

Figure 2. China's dairy production 2000–2014.
Source. Ministry of Agriculture (2013) and Li et al. (2015).

Dairy Consumption

Since 1995, dairy consumption in China has grown at a significant rate, owing to rapid economic growth and increased income. Though Chinese consumers' perceptions of dairy safety had plummeted due to the melamine incident, dairy consumption recovered strongly only nine weeks after the contamination announcement (Wang et al. 2010). Rich, urban Chinese now consume more dairy. Dairy products have already become necessities for many Chinese consumers, especially for children and senior citizens.

A Chinese urban resident typically demands more dairy products than a rural resident due to income difference. In 2014, per capita urban Chinese consumed 18.1 kilograms of fresh milk, increasing by 5.85% from 2013. Rural Chinese only consumed 7.2 kilograms of fresh milk per capita, which is only 39.78% of per capita milk consumption of urban Chinese. Dairy consumption will surely continue to increase because China is currently experiencing fast growth in urbanization. Figure 3 shows the general trends of per capita dairy consumption for rural and urban Chinese dairy consumers between 2000 and 2014.

The Sino-Dutch Dairy Development Centre conducted a dairy consumption survey in 2014 and reported quite different numbers of dairy consumption in China. Per capita dairy consumption by Chinese consumers rose to 35 kilograms in 2014, increasing by 16% from 2010. During the period of 2010-2014, per capita per year dairy consumption of urban Chinese had risen from 36 kilograms to 40 kilograms. Meanwhile, per capita per year dairy consumption of rural residents increased from 19 kilograms to 24 kilograms (Sino-Dutch Dairy Development Centre 2014). Reasons why these survey data are remarkably different from the data published by the Chinese National Bureau of Statistics are stated as followed: (1) Sino-Dutch Dairy Development Centre surveyed consumption of all types of dairy products, while the Chinese National Bureau of Statistics only collected consumption data of fresh milk. (2) Sino-Dutch Dairy Development Centre surveyed householders who are between forty and forty-five years old with relatively high incomes and better education. Consumers with higher incomes and better education usually demand more dairy products than those with lower incomes and less education.

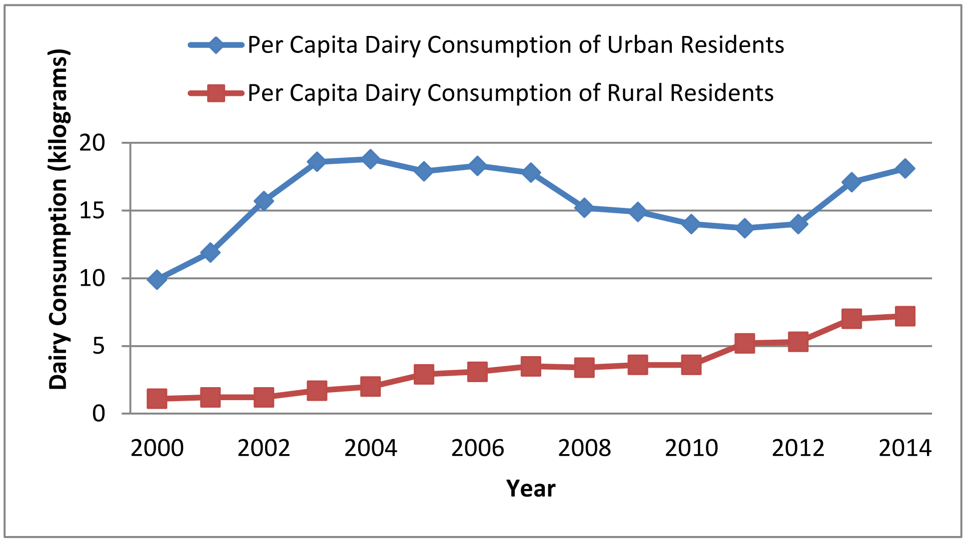

Figure 3. Per capita dairy consumption of Chinese urban and rural residents.
Source. Chinese National Bureau of Statistics, 2015.

Dairy Trade

China's dairy consumption exceeds production and it has a large dairy trade deficit. In 2014, nonfat dry milk consumption in China was equal to 0.30 million metric tons, of which 83.67% was supplied by imports. In the same year of 2014, China produced 1.35 million metric tons of whole milk powder. Total domestic consumption of whole milk powder outweighed production by 0.50 million metric tons (USDA Foreign Agricultural Service 2015).Despite its productivity and resource disadvantages in dairy production, China still exports a small amount of dairy goods. In 2014, dry dairy exports from China reached 13.55thousand metric tons, increasing by 41.5% from 2013. Fluid dairy exports decreased to 26.32 thousand metric tons, which was 0.6% less than the previous year (Liu et al. 2015).

Compared to dairy imports, China's dairy exports are almost insignificant. In 2014, China imported $6.41 billion (all values are in US dollars) of dairy goods, which was 85.38 times the amount of dairy exports (Liu et al. 2015). Dairy imports to China reached a historically high level of 1.93 million metric tons in 2014 with an annual growth rate of 12.8%. Fluid milk imports rose to 0.33 million metric tons, which was 68.8% greater than 2013. Dry dairy imports were 1.48 million metric tons in 2014, increasing by 6.1% from 2013.Imports of infant formula milk powder dropped to 0.12 million metric tons, decreasing by 1.2%. China had a dairy trade deficit of 11.83 million metric tons in 2014. More than 23.5% of Chinese dairy consumption depended on imports (Li et al. 2015).Imports of milk powder grew fastest among all dairy products. Between 2001and 2013, Chinese milk powder imports increased from 59 to 864 thousand metric tons with an annual growth rate of 25.1%.

Dairy products are expensive due to limited supply in China. Price differences of dairy products between China and the international market encourage more dairy imports for China. The world price of raw milk averaged at $25.40/100 kilograms in January 2016, decreasing by 3.8% from December 2015 (IFCN 2016). By contrast, raw milk price was around $54.03/100 kilograms in China's domestic market in January 2016(Chinese Ministry of Agriculture2016). The domestic milk price of China was almost 2.13 times of the international milk price in January 2016. Regional disparities of dairy production and consumption help dairy imports in the east and southeast China (Wang et al. 2010). Table1displaysthe rapid growth of China's dairy imports at the four-digit tariff line level after the melamine incident of 2008.

Table 1. China's dairy imports at the 4-digit tariff line level (million $USD).

Year	HS0401	HS0402	HS0403	HS0404	HS0405	HS0406
2008	12.38	401.44	2.87	311.99	59.22	73.80
2009	19.70	584.38	4.36	284.22	65.67	69.66
2010	28.19	1395.82	4.20	344.81	91.41	105.45
2011	60.49	1656.94	8.92	571.03	183.62	139.08
2012	118.75	1940.74	24.86	746.20	195.66	186.55
2013	234.38	3605.60	40.14	850.96	226.15	231.09
2014	408.55	4459.59	36.50	788.78	378.01	342.40

Note. *HS0401*-milk and cream, not concentrated nor containing added sugar or other sweetening matter; *HS0402*-milk and cream, concentrated or containing added sugar or other sweetening matter; *HS0403*-buttermilk, curdled milk and cream, yogurt, kefir and other fermented or acidified milk and cream. *HS0404*-whey; *HS0405*-butter and other fats and oils derived from milk, and dairy spreads; HS0406-cheese and curd.
Source. World Integrated Trade Solution (WITS/TRAINS).

The melamine incident resulted in destructive damages to the reputations of domestic milk powder brands. Young parents lost faith in the quality and food safety of domestically made milk powder. They began purchasing more milk powder made by foreign producers. In 2007 the market share of imported milk powder was around 35% but it rose to 60% in 2012 in China. Though some domestic milk powder producers such as Beingmate and Biostime run a successful business and enjoy comparatively large market shares, the raw materials for these companies' products are imported. Because of consumption preferences, Chinese cuisines don't use much butter, whey, and cheese. This explains why imports of butter, whey, and cheese have not increased much during 2008–2014.

New Zealand, the United States, Australia, and France are the top four dairy exporters to China. Dairy imports from these top four countries accounted for 83.69% of China's total dairy imports in 2014. New Zealand has consistently been the largest dairy exporter to China since 2001, followed by the United States, Australia, and France (see Figure 4). In 2014, China imported 0.88 million metric tons of dairy products from New Zealand. Imports of milk and cream (concentrated or containing added sugar, HS0402) reached 0.73 million metric tons, accounting for 82.67% of total dairy imports from New Zealand.

The Chinese government encourages dairy imports from countries with rich land and water resources by using bilateral preferential agreements. New Zealand–China and Switzerland–China free trade area (FTA) agreements went into effect on October 1, 2008 and July 1, 2014, respectively. Australia and China also signed a bilateral FTA agreement on June 17, 2014. Regional integration will surely enhance China's dairy imports from these three countries. For example, dairy imports from New Zealand amounted to 0.25 million metric tons in 2009, which was 3.15 times that of dairy imports in 2008. The New Zealand–China free trade area agreement promotes two countries' dairy trade as China's dairy imports from New Zealand expanded from 78,440 metric tons in 2008 to 0.88 million metric tons in 2014, rising by 1023.38% with an annual growth rate of 49.65%.

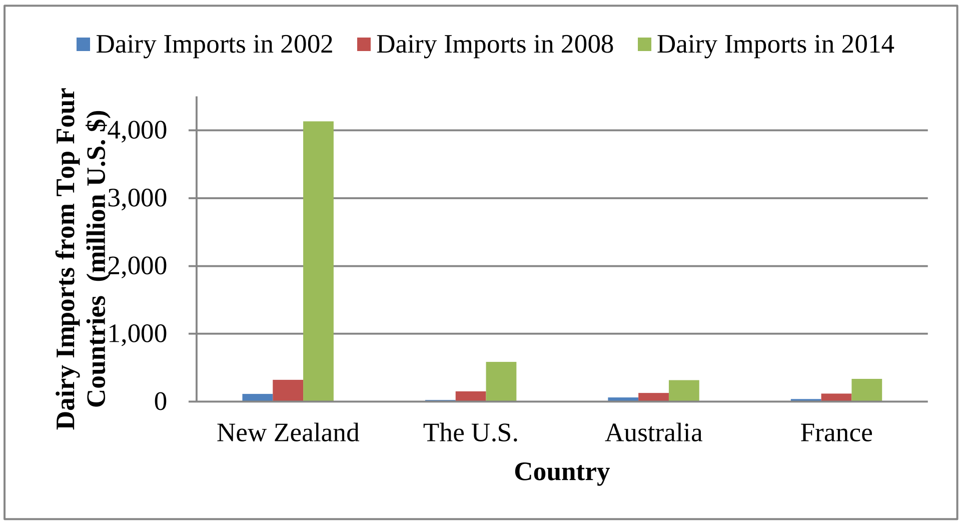

Figure 4. China's dairy imports from top four countries.
Source. World Integrated Trade Solution (WITS/TRAINS).

SPS Measures for China's Dairy Imports

China mainly adopts tariff measures, SPS measures, and bilateral FTAs to manage market access of dairy imports. In order to keep dairy production safe, China issued SPS related measures such as Quality Inspection Regulations for Dairy Products (2008), Development Policy for the Dairy Industry (2009), and Good Manufacturing Practice for Milk (2010).

As of June 30, 2015, China notified the WTO of sixty-one Sanitary and Phytosanitary (SPS) measures and one Technical Barriers to Trade (TBT) on dairy imports. However, only one of the SPS dairy measures has been enacted. The other sixty SPS dairy measures are still at the stage of initiation. Among all dairy exporting regions to China, only the EU expressed a specific trade concern with China's SPS measures for dairy imports. China only uses SPS and TBT measures and does not implement other NTMs such as import licensing, quantitative restrictions, special safeguards, and tariff rate quotas to restrict market access of dairy imports (WTO 2015).

WITS/TRAINS reported that China put forth SPS measures twenty-five times for dairy imports between May 9, 1990 and May 22, 2015. In the same time period, China only implemented two

TBT measures for dairy imports in December, 2005.These two TBT measures prohibited the use of certain toxic chemical elements and formulated tolerance limits for residues of certain substances. China rarely imposed contingent protective measures for dairy imports, with one exception when volume-based agricultural special safeguard measures (WTO 1995) were imposed to restrict dairy imports from New Zealand in 2011.

Before entering the WTO, China implemented SPS measures for dairy imports twelve times. SPS measures performed as the only form of NTMs for China's dairy imports before 2002. After being accepted as a member of the WTO, China reduced its SPS measures for dairy trade by following free trade rules. From the time when China was accepted into the WTO to September 21, 2008, when the melamine incident was reported, China only implemented SPS measures for dairy imports four times. After the melamine incident, China's SPS measures for dairy imports increased. Between September 22, 2008 and May 22, 2015, WITS/TRAINS recorded nine attempts at implementing SPS measures for China's dairy imports.

Table 2. China's SPS Measures for dairy imports during 1990–2001.

NTM Code	Contents of SPS Measures	Start Year	Affected Partners
A140	Special authorization requirement for SPS reasons	1990	Afghanistan, Bhutan, Myanmar, India, Lao PDR, Mongolia, Nepal, Pakistan, Russia, Vietnam
A840	Inspection requirements	1991	The World
A850	Traceability requirements	1992	Mongolia
A830	Certification requirements	1992	Mongolia
A853	Traceability requirements	1992	Mongolia
A830	Certification requirements	1993	Kazakhstan
A210	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	1994	The World
A110	Temporary geographic prohibitions for SPS reasons	1994	Greece
A830	Certification requirements	1995	New Zealand
A110	Temporary geographic prohibitions for SPS reasons	1995	Russia
A850	Traceability requirements	1996	The World
A120	Geographical restrictions on eligibility	1996	The World

Source. World Integrated Trade Solution (WITS/TRAINS).

Before becoming a member of the WTO, China infrequently applied SPS measures to regulate dairy imports because of the small volume of dairy imports. In 2001, China only imported $216.31 million of dairy products, which increased to $861.70 million by 2008.Between 1990 and 2002, most of the twelve SPS measures on dairy imports mainly affected a few neighboring dairy exporters (see Table 2).

After entering the WTO, China opened its dairy market to foreign competitors and reduced the SPS measures regulating dairy trade. Dairy imports accelerated during the period 2002-2008 with an annual growth rate of 21.44%.Table 3 presents the four SPS measures implemented during this time period.

Table 3. China's SPS Measures for dairy imports during 2002–2008.

NTM Code	Contents of SPS Measures	Start Year	Affected Partners
A210	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	2002	The World
A110	Temporary geographic prohibitions for SPS reasons	2004	The World
A820	Testing requirements	2005	The World
A210	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	2005	The World

Source. World Integrated Trade Solution (WITS/TRAINS).

After the melamine incident in 2008, China strengthened food safety inspection and quality tests on dairy production. Between August 1, 2008 and March 1, 2015, China published forty-four dairy safety related standards. Most of these standards are instructions for testing chemical elements and nutrients in dairy products. China also imposed SPS measures to regulate dairy imports more frequently than before the melamine incident (see Table 4).

Table 4. China's SPS Measures for dairy imports during 2008–2015.

NTM Code	Contents of SPS Measures	Start Year	Affected Partners
A410	Microbiological criteria of the final product	2010	The World
A420	Hygienic practices during production	2010	The World
A83	Certification requirements	2010	The World
A210	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	2011	The World
A220	Restricted use of certain substances in foods and their contact materials	2011	The World
A410	Microbiological criteria of the final product	2011	The World
A820	Testing requirements	2011	The World
A310	Labeling requirements	2012	The World
A64	Storage and transport conditions	2015	The World

Source. World Integrated Trade Solution (WITS/TRAINS).

Methodology and Data

Trade Restrictiveness Index Model

China reduced tariff rates for dairy imports after the melamine incident but increased the frequencies of SPS measures to control dairy imports. China also strengthened domestic support to the dairy sector by subsidizing alfalfa cropping, large scale and standard dairy production, and large dairy firms' acquisitions of small firms (Qian et al. 2011; Jia et al. 2012). Both market access and domestic support measures may affect China's dairy imports. Major dairy exporting countries such as New Zealand and the United States may face potential market access difficulties in increasing sales to China's market due to SPS measures and other NTMs.

This paper takes SPS measures as the only form of market access barrier for China's dairy imports by isolating it from the occasional presences of other NTMs. China has seldom employed TBTs, special safeguard measures, and other NTMs to restrict dairy imports. Accordingly, China's dairy trade policies consist of tariff rates, SPS measures, and domestic support.

SPS measures and domestic support in China's dairy trade policies take on many forms, and analysts cannot sum these measures directly to assess their impacts on China's dairy imports. First, one has to transform these SPS and domestic support measures into AVEs of tariff rates. Then, the addition of tariff rates and AVEs of SPS and domestic support measures constitute barriers to dairy trade in China. The restrictiveness of trade policies for China's dairy imports depends on import demand elasticities of dairy products in China's consumption market. High tariff rates and AVEs of SPS measures may not impede China's dairy imports when dairy imports are inelastic.

This paper follows the trade restrictiveness index method developed by Kee et al. (2009). The trade restrictiveness index model is preferred to the other methods in literature because it is grounded in economic theory. Kee et al. (2009) estimated import demand elasticities of around 4,900 goods by applying the GDP optimization function. However, one drawback of the trade restrictiveness index method is its inability to disentangle domestic dairy support policies at the six-digit tariff line level.

The functional specification that Kee et al. (2009) derived to estimate the TRI is

$$(1)\ \ln m_{n,c} = \alpha_n + \sum_k \alpha_{n,k} C_c^k + \beta_{n,c}^{Core} Core_{n,c} + \beta_{n,c}^{DS} \ln DS_{n,c} + \varepsilon_{n,c} \ln\left(1 + T_{n,c}\right) + \mu_{n,c}$$

where $m_{n,c}$ is the imported quantity of good n in country c; α_n are tariff line dummies that capture any good-specific effect; C_c^k are k variables of country characteristics; $Core_{n,c}$ is a dummy variable indicating the presence of a core NTM; $DS_{n,c}$ is the volume of agricultural domestic support; $\varepsilon_{n,c}$ is the import demand elasticity of good n in country c; $T_{n,c}$ refers to the overall level of protection imposed by country c on good n, which is the addition of AVE and the tariff rate of good n in country c.

Differentiate (1) with respect to $Core_{n,c}$ and $lnDS_{n,c}$ gives

$$(2)\ \frac{\partial \mathrm{lnm_{n,c}}}{\partial \mathrm{Core_{n,c}}} = \frac{\partial \mathrm{lnm_{n,c}}}{\partial \mathrm{lnp^{d}_{n,c}}}\frac{\partial \mathrm{lnp^{d}_{n,c}}}{\partial \mathrm{Core_{n,c}}} = \varepsilon_{\mathrm{n,c}}\mathrm{ave^{Core}_{n,c}}$$

$$(3)\ \frac{\partial \mathrm{lnm_{n,c}}}{\partial \mathrm{lnDS_{n,c}}} = \frac{\partial \mathrm{lnm_{n,c}}}{\partial \mathrm{lnp^{d}_{n,c}}}\frac{\partial \mathrm{lnp^{d}_{n,c}}}{\partial \mathrm{lnDS_{n,c}}} = \varepsilon_{\mathrm{n,c}}\mathrm{ave^{DS}_{n,c}}$$

where $\mathrm{p^{d}_{n,c}}$ is the price index of good *n* in country $c, ave^{Core}_{n,c}$ and $ave^{DS}_{n,c}$ are the ad valorem equivalents of core NTMs and domestic support imposed on good *n* in country *c*, respectively. $ave^{Core}_{n,c}$ and $ave^{DS}_{n,c}$ can be calculated by solving (2) and (3):

$$(4) ave^{Core}_{n,c} = \frac{1}{\varepsilon_{n,c}}\frac{\partial lnm_{n,c}}{\partial Core_{n,c}} = \frac{e^{\beta^{Core}_{n,c}-1}}{\varepsilon_{n,c}}$$

$$(5)\ ave^{DS}_{n,c} = \frac{1}{\varepsilon_{n,c}}\frac{\partial lnm_{n,c}}{\partial lnDS_{n,c}} = \frac{\beta^{DS}_{n,c}}{\varepsilon_{n,c}}$$

Equations of TRI, OTRI and MA-OTRI

Kee et al. (2009) defined the TRI and the OTRI, respectively, as

$$(6) \mathrm{TRI_C} = \left(\frac{\sum_{\mathrm{n}} \mathrm{m_{n,c}}\varepsilon_{\mathrm{n,c}}\mathrm{T^2_{n,c}}}{\sum_{\mathrm{n}} \mathrm{m_{n,c}}\varepsilon_{\mathrm{n,c}}}\right)^{\frac{1}{2}}$$

$$(7)\ \mathrm{OTRI_C} = \frac{\sum_{\mathrm{n}} \mathrm{m_{n,c}}\varepsilon_{\mathrm{n,c}}\mathrm{T_{n,c}}}{\sum_{\mathrm{n}} \mathrm{m_{n,c}}\varepsilon_{\mathrm{n,c}}}$$

Next the MA-OTRI of good *n* experienced by the exporting country *c* in the importing country *p* is defined on a bilateral basis with *p* indicating China.

$$(8)\ \mathrm{MA-OTRI_c} = \frac{\sum_{\mathrm{p}}\sum_{\mathrm{n}} \mathrm{m_{n,c,p}}\varepsilon_{\mathrm{n,p}}\mathrm{T_{n,c,p}}}{\sum_{\mathrm{p}}\sum_{\mathrm{n}} \mathrm{m_{n,c,p}}\varepsilon_{\mathrm{n,p}}}$$

Stringent trade policies reduce trade volumes by increasing trade costs and the prices of traded commodities. The area of a *Harberger Triangle* represents the dead weight loss ($\mathrm{DWL_c}$) of welfare for an importing country:

$$(9)\ \mathrm{DWL_c} = \frac{1}{2}(\mathrm{TRI_c})^2\mathrm{GDP_c}\sum_{\mathrm{n}} \mathrm{s_n}\ \varepsilon_{\mathrm{n,c}}$$

where $\mathrm{GDP_c}$ is the gross domestic product of the importing country and s_n is the share of good *n* imports in $\mathrm{GDP_c}.s_n$ is negative because imports reduce GDP in a demand-side GDP equation.

Data

This paper employs AVEs and import demand elasticities for China's dairy imports from Kee et al. (2009). The authors did not estimate the AVEs and import demand elasticities for China's dairy imports for three reasons: (1) China is the only importing country analyzed. (2) The panel data for country specific prices and endowments in the imports-share function in Kee et al. (2009) are not available, which make estimation of the AVEs and import demand elasticities for China's dairy imports impossible. (3) Import demand elasticities usually do not change over a short period of time.

AVEs and import demand elasticities estimated in Kee et al. (2009) cover nine dairy products at the six-digit tariff line level (see Table 5). AVEs and import demand elasticities for the other eleven dairy goods at the six-digit tariff line level were not estimated by Kee et al. (2009) due to data limitation. Data of China's dairy imports and tariff rates are retrieved from the website of the World Integrated Trade Solution (WITS/TRAINS).

Table 5. Tariff rates, Import Demand Elasticities, and AVEs for China's imports of nine dairy products.

HS Code	Applied MFN Tariff Rate in 2002 (%)	Applied MFN Tariff Rate in 2008 (%)	Applied MFN Tariff Rate in 2014(%)	Preferential Rate for New Zealand in 2014 (%)	Preferential Rate for Switzerland in 2014 (%)	Import Demand Elasticities	AVEs
040110	19	19	15	0	13	-8.12	0
040120	19	19	15	4.5	13	-4.32	0
040221	17	17	10	4	10	-1.61	0.62
040229	17	17	10	4	8	-10.09	0
040310	26	26	10	0	9.2	-76.82	0
040410	6	6	2	0	2	-0.85	0
040490	32	32	20	0	20	-158.33	0
040620	27	27	12	0	9.8	-2.89	0
040690	27	27	12	3	9.8	-7.40	0
Arithmetic Average	21.11	21.11	11.78	1.72	10.53	NA	NA
Weighted Average	12.70	11.91	9.09	3.94	11.59	NA	NA

Note. *HS040110*-milk and cream, of a fat content, by weight, not exceeding 1%; *HS040120*-milk and cream, of a fat content, by weight, exceeding 1% but not exceeding6%; *HS040221*-milk and cream, concentrated, not containing added sugar or other sweetening matter; *HS040229*-milk and cream, concentrated, other; *HS040310*-yogurt; *HS040410*-whey and modified whey, whether or not concentrated or containing added sugar or other sweetening matter; *HS040490*-whey and modified whey, other; *HS040620*-grated or powdered cheese, of all kinds;*HS040690*-other cheese.

Source. Tariff rates are from WITS/TRAINS. Import demand elasticities and AVEs are from Kee et al. (2009).

Table 5 also lists preferential tariff rates for China's dairy imports from New Zealand and Switzerland. Preferential tariff rates for dairy imports from Australia are not reported because the Australia-China FTA has not passed in the Australian parliament. However, China set the average preferential tariff rate for dairy imports from New Zealand at 2.24%when New Zealand-China FTA took effect in 2008. Also, note that preferential tariff rates for dairy imports from Switzerland average 10.34%, which is only 13.85% lower than China's average most-favored-nation (MFN) tariff rate.

China's applied MFN tariff rates for twenty dairy goods (HS040110-HS040690) at the six-digit tariff line level averaged 24.48%in 2002. The weighted average tariff rate of these twenty dairy goods was equal to 13.55% in 2002. The applied MFN tariff rates for China's dairy imports remained unchanged through 2008, but the weighted average tariff rate increased to 14.37%. The melamine incident damaged consumer confidence with domestically produced dairy goods, especially infant formula milk powder. To stabilize the domestic dairy supply, China liberalized its dairy market further by reducing tariff rates for dairy imports in 2009. By 2014, the average MFN tariff rate for China's dairy imports was lowered to 12%. At the same time, the weighted average tariff rate for dairy imports decreased to 9.52%.

Results

This paper calculates TRIs, OTRIs, and MA-OTRIs for China's dairy imports for nine dairy goods at the six-digit tariff line level in three critical years, i.e., 2002, 2008 and 2014. The TRI, OTRI, and MA-OTRI for China's dairy imports in 2002 establish a benchmark of China's dairy trade policies shortly after its accession to the WTO, while the TRI, OTRI and MA-OTRI for 2008reveal the progress that China achieved in opening up its dairy market by following WTO rules. Finally, the three trade restrictiveness indexes for 2014showhow China responded to the melamine incident by utilizing trade policies such as SPS measures.

TRIs for China's Dairy Imports

The TRI represents the uniform tariff equivalent for the current structure of protection that leaves the importing country's welfare unchanged (Kee et al. 2009). In 2002, the TRI for China's dairy imports reached 40.71% (see Table 6), which was 82.23% greater than the average MFN tariff rate and 220.04% greater than the weighted average tariff rate, respectively.

Table 6. The TRIs for China's dairy imports in critical years.

Year	TRI Tariffs Only	TRI Tariffs and SPS Measures	Dead Weight Loss Tariffs Only Million $USD	Dead Weight Loss Tariffs and SPS Measures Million $USD
2002	0.1876	0.4071	2.7365	12.8864
2008	0.2606	0.3960	6.2030	14.3232
2014	0.1319	0.4934	7.4517	104.2706

Though tariff barriers for China's dairy imports decreased because of WTO accession, non-tariff barriers still exist, especially for imports of concentrated milk and cream. Kee et al. (2009) reported that AVEs of NTMs for HS040210 (milk and cream, in powder, granules or other solid forms, of a fat content, by weight, not exceeding 1.5 %) and HS040221 (milk and cream, concentrated, not containing added sugar or other sweetening matter) were equal to 56.05%and 61.94%, respectively. The AVEs of these two dairy products are much higher than ad valorem tariff rates. Because SPS measures are the main type of NTMs for China's dairy imports, SPS measures were more restrictive than tariff rates.

Table 5 shows that, except for HS040410, imports of the other eight dairy products at the six-digit tariff line level are price elastic. Price increases brought about by the restrictiveness of tariff and SPS measures will impede China's dairy imports remarkably. As a result, Chinese consumers will have to substitute domestic dairy products for the imported ones when dairy imports are restricted. Stringent dairy trade policies represented by SPS measures will encourage domestic dairy production and increase producers' surplus at the expenses of consumers.

Column 2 of Table 6 presents the TRIs of tariffs for China's dairy imports in 2002, 2008, and 2014, respectively. Column 3 of Table 6 lists the TRIs of tariffs and SPS measures for China's dairy imports for each of the three critical years. Kee et al. (2009) reported that TRIs (tariffs) and TRIs (tariffs and NTMs) for China's general imports were equal to 0.211 and 0.343, respectively. Therefore, compared with general imports, China's dairy imports are more restrictive.

Between the years2002-2008, the TRI (tariffs and SPS measures) declined to 39.60% from 40.71%. This decrease in TRIs implies that China continued to open up its dairy industry and China's trade policies became less restrictive. Participation in the multilateral trading system resulted in China further liberalizing its dairy trade. Frequencies of SPS measures and other NTMs decreased in this time period. Though import demand elasticities and ad valorem tariff rates were unchanged between 2002 and 2008, the TRI (tariff only) increased from 18.76% to 26.06% because of the Chinese consumers' strong demand for the imported dairy products with higher income.

The melamine incident resulted in a substantial decline of the Chinese consumer confidence in the dairy industry. Young Chinese mothers responded by reducing purchases of domestic infant formula milk powder. High income consumers switched to dairy goods from developed countries. The central government realized that the melamine incident not only hurt consumers' welfare, but also threatened national dairy security. The government liberalized its dairy trade polices after the melamine incident by reducing the tariff rates for dairy imports. The average MFN tariff rate for dairy imports decreased from 24.48% in 2008 to 12% in 2009. Lower tariff rates stimulated dairy imports. The TRI (tariffs only) decreased dramatically from 26.06% in 2008 to 13.19% in 2014, which was only 9.92% greater than the average MFN tariff rate.

Another effect of the melamine incident was that China began using SPS related measures more frequently to regulate both dairy production and imports. The original purpose of imposing these SPS related measures was to ensure dairy food safety, but SPS measures did impede China's dairy imports and reduce consumers' welfare. The TRI (tariffs and SPS measures) for China's dairy imports increased to 49.34% in 2014, 311.19% greater than the average MFN tariff rate. Tariff and SPS barriers for China's dairy imports caused a dead weight welfare loss of $104.27 million in 2014. However, tariff barriers for China's dairy imports gave rise to a dead weight welfare loss of only$7.45 million in the same year of 2014. Compared with tariff barriers, SPS measures exerted a larger negative effect on dairy imports and welfare.

OTRIs for China's Dairy Imports

The OTRI represents the uniform tariff equivalent that could replace existing protections while leaving imports unchanged (Kee et al. 2009). In 2002, the OTRI for China’s dairy imports reached 31.29%, which was 47.12% and 146.39% greater than the average MFN tariff rate and the weighted average tariff rate, respectively (see Table 7). Kee et al. (2009) reported that OTRI (tariffs only) and OTRI (tariffs and NTMs) for China's general imports were equal to 0.140 and 0.204, respectively. The OTRIs (tariffs only) for China's dairy imports estimated in this paper are comparable to the OTRIs (tariffs only) for general imports estimated by Kee et al. (2009). But the OTRIs (tariffs and SPS measures) for China's dairy imports are much greater than the OTRIs (tariffs and NTMs) for general imports. Table 7 reconfirms that SPS measures do restrict China's dairy imports.

Table 7. The OTRIs for China's dairy imports in critical years.

Year	OTRI (Tariffs Only)	OTRI (Tariffs and SPS Measures)
2002	0.1783	0.3129
2008	0.2441	0.3358
2014	0.1235	0.3994

During 2002-2008, though MFN tariff rates for dairy imports remained unchanged, the OTRI (tariffs and SPS measures) for dairy imports increased from 31.29% to 33.58%. China only implemented SPS measures four times and TBT measures two times for dairy imports in this time period. These small numbers of SPS and TBT measures increased the overall trade restrictiveness for China’s dairy imports by7.32%.

The OTRI (tariffs and SPS measures) for China’s dairy imports continued to rise after the melamine incident, reaching 39.94% in 2014, which was 239.05% greater than the average MFN tariff rate. In the short amount of time between September 22, 2008 and May 22, 2015, China implemented SPS measures nine times for dairy imports. China also adopted one special agricultural safeguard measure for dairy imports from New Zealand on July 1, 2011. Both SPS measures and special agricultural safeguard impede China's dairy imports, not taking other determinants of imports into consideration.

Chinese legislatures and government agencies continue to publish new food standards for the dairy industry in order to guarantee dairy food safety and quality. These dairy food standards can form SPS measures for dairy imports. The earliest dairy food standard traces back to the Method of Test for Milk and Milk Products that took into effect on June 4, 1969. From December 1, 1985 to March 1, 2015, China promulgated sixty-seven food standards for dairy production and imports. Ten food standards for dairy exports were also issued. These food standards are relevant to testing methods, green dairy food production, dairy marketing, maximum residue limit of chemical elements, Hazard Analysis and Critical Control Point (HACCP) system, and Good Agriculture Practice (GAP) in dairy firms. Following the melamine incident, China issued forty-one dairy food standards, which accounted for 60.29% of the total between October 1, 2008 and March 1, 2015 (Zhejiang Institute of Standard 2015).

MA-OTRIs for Major Dairy Exporting Countries to China's Market

China's strong demand for dairy products provides major dairy exporting countries with opportunities to expand their exports. At the present time, China imports most of its dairy goods from New Zealand, the United States, Australia, and France. The Chinese government wants to realize dairy security by exploring new sources of dairy imports from the international market. Between 2002 and 2014, the top ten dairy exporters to China included Argentina, Australia, Denmark, France, Germany, Ireland, New Zealand, the Netherlands, Switzerland, and the United States.

The market access difficulties of these top ten dairy exporters to China's market vary. Ireland, Switzerland, and the United States enjoyed the lowest level of market access barriers in exporting dairy goods to China. However, the MA-OTRIs of Argentina, Australia, Denmark, Germany, and the Netherlands are greater than the average MFN tariff rate of 12%. Meanwhile, the MA-OTRI of France is almost equal to China's average MFN tariff rate (see Figure 5).

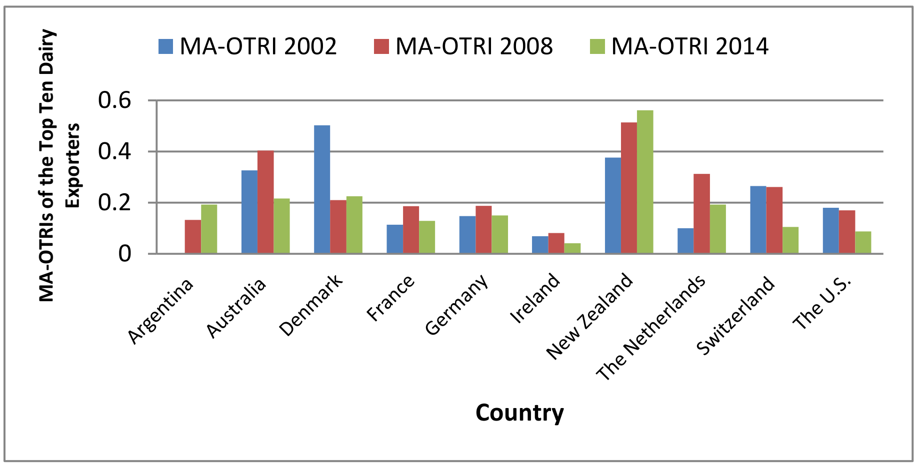

Figure 5.MA-OTRIs for the top ten dairy exporters to China in critical years.

The arithmetic averages of MA-OTRIs (tariffs only) and MA-OTRIs (tariffs and NTMs) for China's general imports reach 0.0204 and 0.066, respectively (Kee et al. 2009). The MA-OTRI (tariffs only) and the MA-OTRI (tariffs and SPS measures) for China's dairy imports were equal to 0.1186 and 0.1905, respectively, in 2014. The Estimated MA-OTRIs in Figure 5 indicate that China's dairy imports are more restrictive than general imports. Dairy exporters face comparatively high market access barriers to China.

Market access barriers for dairy imports from Denmark decreased dramatically between 2002 and 2014. In 2014, the MA-OTRI of Demark was 0.2256, which was 44.81% of the MA-OTRI in 2002. Closer bilateral economic cooperation at the government and firm level explains rapid increase in market access for Danish dairy exports to China. The Danish government helps its dairy firms' exports to China. The Danish Agriculture and Food Council and the Chinese Ministry of Agriculture established a Sino-Denmark Dairy Research and Development Centre in 2012. With this platform of dairy technology innovation, dairy firms in both countries are able to cooperate in areas such as dairy farm management, dairy safety management, and human capacity building.

Danish dairy firms have realized the importance of China's market and are trying to expand dairy sales to China. As the largest dairy producer in Denmark, Arla Foods implemented successful marketing strategy in China by establishing a close cooperative relationship with Hunan-based Engnice in 2012.In the Chinese domestic market, Engnice's brand of "SMILE" uses 100% of imported milk powder from Denmark. Arla Foods is also dedicated to exporting whey and cheese to China. In 2014, Arla Foods and Mengniu Group set up a joint cheese innovation center. Arla Foods also cooperates with China National Cereals, Oils, and Foodstuffs Corporation (COFCO) in investing in China's dairy industry. In 2012, Arla Foods became the third largest shareholder of Mengniu Group (a subsidiary company of COFCO). Denmark's dedication has paid off. In 2014, Danish exports of concentrated milk and cream to China reached $31.89 million, 1,129.81 times that of 2008. Danish whey exports to China equaled $7.25 million in 2014, 5.40 times that of 2008. China's cheese imports from Denmark amounted to $8.95 million in 2014, increasing by 462.98% from 2008.

Interestingly, New Zealand has the highest MA-OTRIs among the top ten importing countries. New Zealand is the largest supplier of concentrated milk and cream to China. In its total dairy exports to China, the proportions of concentrated milk and cream were equal to 65.78%, 41.84%, and 73% in the respective year of 2002, 2008 and 2014. There are two reasons that can explain high MA-OTRIs for New Zealand: (1) China imports milk powder from New Zealand mainly for baby and child consumption. Sanitary requirements and standards for infant milk imports are higher than those of adult dairy products. (2) Though the New Zealand-China free trade area agreement took effect in 2008, China can still use other forms of trade policies to restrict dairy imports from New Zealand. In August 2013, China put an embargo on lactalbumin powder imports from New Zealand because of a botulin toxin contamination report of Fonterra. China did not lift this embargo until November2014. China also imposed a special safeguard measure on dairy imports from New Zealand. According to the New Zealand-China free trade area agreement, the trigger criterion for imports of concentrated milk and cream from New Zealand is 0.14 million metric tons during 2015. But only by January 5, 2015, Chinese firms had declared 0.18 million metric tons of imports to customs. Beginning on January 7, 2015, imports of concentrated milk and cream from New Zealand applied to MFN tariff rates other than preferential tariff rates. Quotas of dairy imports from New Zealand were also quickly used up between 2009 and 2014. Non-tariff barriers such as SPS measures, safeguard measures, licensing and quota systems made dairy exports of New Zealand to China unstable.

Concluding Remarks

China's dairy demand is exceedingly large. To ensure dairy security, China has to continuously increase the production capacity of its own dairy industry and improve both domestic and foreign trade policies. Dairy consumption in China will continue to grow but China does not have a comparative advantage or a natural endowment advantage in dairy production. Opening up the dairy market to international competitors will lead to a net welfare gain for China. The melamine incident makes dairy food safety a hot issue in China. To ensure dairy safety, China has issued many SPS related domestic measures. SPS measures have already become the major type of NTMs that determine the TRIs, OTRIs and MA-OTRIs for China's dairy imports. Though unintentionally, these SPS related domestic measures may reduce China's dairy imports and reduce consumers' welfare.

Findings of this paper include: (1) SPS measures are the main type of NTMs for China's dairy imports. (2) SPS measures are more restrictive than tariff rates for China's dairy imports and caused significant welfare losses to China. (3) Major dairy exporters still face high market access barriers to China.

The limitations of this paper are twofold. First, the import demand elasticities taken from the literature do not vary with time and only cover nine of twenty dairy products at the six-digit tariff line level. Second, statistics of NTMs by WITS/TRAINS is limited. This databank misses or neglects the existence of other NTMs for China's dairy imports such as licensing, quotas, and domestic support on dairy production. Future work may be done in the following four directions: (1) Collect and sort out all NTMs relating to China's dairy trade, especially domestic support policies. (2) Estimate new import demand elasticities and AVEs for all twenty dairy products at the six-digit tariff line level. (3) Analyze the restrictiveness of China's dairy trade policies on a bilateral basis. (4) Analyze the restrictiveness of China's dairy trade policies at the firm level.

In the short run, SPS measures restrict and reduce China's dairy imports if other determinants such as income and price are not considered. Domestic dairy producers benefit from SPS measures for dairy imports. Consumer welfare decreases due to income and substitution effects. In general, SPS measures cause a net welfare loss for China. In the long run, SPS measures for China's dairy imports may decrease competitiveness of its domestic dairy producers. SPS measures make resource allocation efficiency low in domestic dairy production. Meanwhile, SPS measures for China's dairy imports may have positive impacts on large foreign dairy exporters with popular brands. Once these large dairy exporters assimilate extra adjustment costs in meeting China's SPS standards, they will enjoy a greater market share in China's dairy market.

China needs to import more dairy goods. Free dairy trade increases welfare to both the exporting countries and China. It is not rational for China to unnecessarily distort the dairy market with trade policies such as SPS measures. Less regulated dairy imports do not conflict with China's national food security strategy and can secure a robust, consistent food supply.

China's SPS measures for dairy imports should be made in compliance with international standards. The World Organization for Animal Health (OIE), International Plant Protection Convention (IPPC), and Codex Alimentarius (CAC) have already published standards for dairy production. These standards provide benchmarks for Chinese SPS measures. Although China does not need to adopt all of these international standards, they could stand as a key framework from which to construct future dairy trade policy. Foreign direct investment and green-box financial support are two good substitutes for SPS measures.

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The Effects of Trade Liberalization on Dairy Trade and Domestic Milk Production in CARICOM

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Abstract

Domestic milk production in the major CARICOM states appears to be in crisis, with shrinking domestic production and increasing milk imports. This paper therefore investigates the impact of trade liberalization on domestic milk production and imports in Jamaica, Trinidad and Tobago and Barbados and determines trade factors that influence changes in these variables. The study demonstrates the dominance of dairy imports into CARICOM from New Zealand and the EU and the significant effects of trade liberalization in causing structural changes in domestic milk production and imports in the cases of Barbados and Jamaica. Changes in GDP per capita highly influence changes in milk imports for the three countries and for Jamaica also the price of imported powdered milk. The *Nestle* countries, Jamaica, and Trinidad and Tobago show greater declines in milk production than Barbados, therefore further research is recommended on the role of *Nestle* in the Caribbean milk industry.

Keywords: milk production, imports, trade liberalization, Caribbean

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Introduction

The CARICOM Dairy Industry

Little has been written about the Caribbean dairy industry since Aneja (1993). According to Aneja, the region (with a population of approximately 35 million) is one of the world's largest export markets for dairy products (20–25% of the world exports) and has a per capita consumption of milk of about 60kg per annum which is comparable with India's (Aneja 1993). He also states that local production then accounted for approximately 60% of total Caribbean milk consumption, with milk prices at US $1 per liter being among the highest in the world and a farm gate price of $0.25 per liter being lower than farm gate prices for milk producers in developed countries in Europe and North America (Aneja 1993).

The member states of the Caribbean Community (CARICOM) have never been major producers of milk and have imported substantial quantities of their dairy requirements. However there have been programs in the major states to increase milk production. One outstanding example of such a program is the State Lands Development Program in Trinidad and Tobago (Ministry of Agriculture, Land and Marine Resources 2005). The main fresh milk producers in the Caribbean region are Jamaica, Barbados, Trinidad and Tobago, Guyana and the Dominican Republic. The dairy industries of Jamaica and Trinidad and Tobago are organized around the multinational firm, Nestle Caribbean Ltd., headquartered in the Dominican Republic, whereas in Barbados, the industry is centered on a local firm, the Barbados Dairy Industries Limited.

The majority of the CARICOM states became members in 1995 of the World Trade Organization (WTO) and complied with the stipulations for membership under the Uruguay Round of GATT, which required the lowering of duties on the imports of agricultural commodities. Even prior to 1995 however: "Caribbean economies adopted liberal trade policies in the latter 1980's and (early) 1990's often as conditionalities for accessing finance from the International Monetary Fund (IMF) and the World Bank in the wake of macroeconomic disequilibrium" (ECLAC 2007). Even prior to 1995 also there appears to have been a drop in milk production and an increase in milk imports into the Caribbean. This paper examines these trends in the three major producing countries with organized dairy industries in CARICOM: Jamaica, Trinidad and Tobago and Barbados which have the "status as net-importers of basic foodstuffs" (WTO 2012). The paper also determines if there exists any relationship between these trends in the dairy industry in the Caribbean and trade liberalization.

Fresh milk in the Caribbean is largely produced by small farmers using a mixture of hand and machine milking (CTA 2012). Feeding systems vary but usually include a mixture of pastures (some with improved grasses) and high levels of concentrate feed, along with cut-and-carry systems (where feed is cut/gathered and taken to the cattle) (CTA 2012). Goat milk production by small producers is also a feature of the Caribbean dairy industry, especially with door to door delivery in rural areas. These producers often also rear small herds of sheep. However the lack of reliable information precluded an analysis of goat milk production and trade in this study.

Domestic milk production in several major Caribbean states became closely linked to the Swiss company *Nestle*, which introduced technologically advanced, consumer-ready milk packaging, most notably Tetra Pak packaging technology. *Nestle* Trinidad and Tobago Ltd. also initiated production of evaporated milk in Tetra Pak packaging in 1989 (CTA 2000). *Nestle* has subsidiaries in Trinidad and Tobago, Jamaica, Puerto Rico and the Dominican Republic (*Nestle* Caribbean 2015).[1] In Trinidad and Tobago, the company also administers the state's milk price support program.

Barbados Dairy Industries Ltd. (BDIL) was established as a joint venture between the Government of Barbados, Northern Dairies of England, a Barbadian private enterprise and the New Zealand Dairy Board in 1966 (Banks Holdings Ltd.). Approximately 40% of local milk production was purchased by BDIL between 1970 and 1992, with this level increasing to almost 75% after 1993 (Kellman 2011). Banks Holding Limited acquired the BDIL in 1997, making it a wholly local enterprise, and the lone dairy processing plant on the island, with a collective capacity of 15,000 liters of milk per day. The processing plant controlled the supply of fresh milk through a quota system for the dairy farmers. The processing plant however suspended the milk quota system in July 2011 paying the full price for all milk (Barbados Dairy Industries Ltd. 2011). This resulted in an increase in milk supply and an ensuing milk glut, which forced the firm to re-instate the quota system from 1-July 2012 and to state that reform is needed in the fresh milk industry if the dairy farmer and the processor are to achieve growth (Barbados Dairy Industries Ltd. 2013). One of the major challenges to the industry identified by the company is the increasing input costs due to the relatively high cost of raw milk from local farms, as compared to imports of powdered milk-based products (Barbados Dairy Industries Ltd. 2013).

The shortfall of local milk production in the Caribbean has traditionally been met through imports of milk powder and other processed forms of milk from the United Kingdom, Canada, New Zealand, Denmark, the United States of America, as well as other countries. In recent years however there have been increasing imports of liquid products including 'fresh' ultra-heat treated (UHT) milk and other milk drinks, aided in large measure by government policies to enhance access to "cheap foods" (CTA 2012). Also, according to the CTA (2012) "notwithstanding high production costs and operational efficiency considerations, trade liberalization is widely blamed by Caribbean milk producers for the big contraction in the size of domestic dairy industries in all Caribbean dairy producing countries. In Trinidad and Tobago, for example, local milk production fell from 52% of consumption to 27% between 2000 and 2010. This can be taken as indicative of a general trend across the Caribbean" (CTA 2012). CTA (2012) concludes as follows: "(Thus) despite the efforts of dairy farmers, local processors and governments, by the end of 2011 the dairy industry in Caribbean countries, particularly local fresh milk production, was described as one of crisis, with dwindling profits, shrinking markets, no incentives and a lack of clear rules for the management of milk powder imports."

Objectives of the Paper

This paper has three objectives, the first of which is to trace the recent trends in domestic milk production and milk imports in three major producing states of CARICOM, Trinidad and Tobago and Jamaica as *Nestle* dairy states and Barbados with a dominant, locally owned dairy firm. The second objective is to determine the influence of trade liberalization on milk imports and the level of domestic milk production in the three CARICOM states. Specifically the paper assesses whether trade liberalization, including membership in the WTO has been a major influence on

[1] The Nestle website unlike most progressive international firms is almost bereft of relevant corporate information.

reducing domestic milk production in the Caribbean. The third objective is to determine and compare factors that have influenced changes in the level of production and exports for milk and milk products in the three CARICOM states.

The paper in the first instance provides a detailed review of the trends in milk production and imports in the major dairy producing states in CARICOM, utilizing mainly FAOSTAT data (FAOSTAT). The literature is examined to determine factors that have been hypothesized to affect milk production and imports in the region. Then Vector Autoregressive Models for Multivariate Time Series (VAR) analysis is utilized to examine the relationships between time series of these factors or variables and milk production and imports in the Caribbean. This analysis includes the determination of Granger causality between the time series. Chow tests are also used to detect structural changes in dairy imports and milk production in the Caribbean which may be attributable to the impact of trade liberalization.

Trends in Production and Trade

Production

As seen in Figure 1, Jamaica has been the largest CARICOM milk producing state with milk production attaining a peak of 53,000 tons in 1991.[2] From 1991 however, there has been a major fall off in production which declined to 12,500 tons by 2013. Miller, Ffrench, Duffus and Jennings (2007) report that the Jamaican dairy sector recorded a decline in annual output of milk of approximately 63% since trade liberalization in 1992, primarily because of the inability of the local industry to compete with imports of dairy products (principally powdered milk), which “enjoyed massive producer and export subsidies at origin”. They suggest that without effective countervailing measures to minimize trade distortions in the local market, the local industry was unable to compete with dumped substitutes, which reached the market place at retail prices as low as 45% below the price of locally produced fresh milk (fluid equivalent basis), even after the local trade had extracted retail margins (over FOB) as high as 118% (Miller, Ffrench, Duffus and Jennings 2007).

In another article, Rendleman (2011) states that in the late 1980s, Jamaica had a successful milk industry, in part because of policies that increased tariffs on imported milk powder. The tariff revenue was passed on to local dairy producers as a subsidy. Rendleman (2011) also states that in 1992, the World Bank required Jamaica to lift the tariff on imported milk powder as a condition for granting a loan. “Soon enough, Jamaica was flooded with imported, heavily-subsidized powdered milk. The milk powder wasn't all bad though because it was cheaper and didn't require refrigeration, which benefited poor families. On the other hand, the destruction of the local dairy industry weakened the long-term food security of Jamaica” (Rendleman 2011). In a similar vein CTA (2012) reports that the Jamaica Dairy Development Board and the Beef and Dairy Producers’ Association of Jamaica openly stated in 2009 that the Jamaican dairy sector has undergone severe attrition, consequent to the adoption of a policy of trade liberalization in 1992, resulting in milk production declining 64% to current levels bordering on 14 million liters per annum.

[2] In this paper 1 ton = 1,000kg or metric ton.

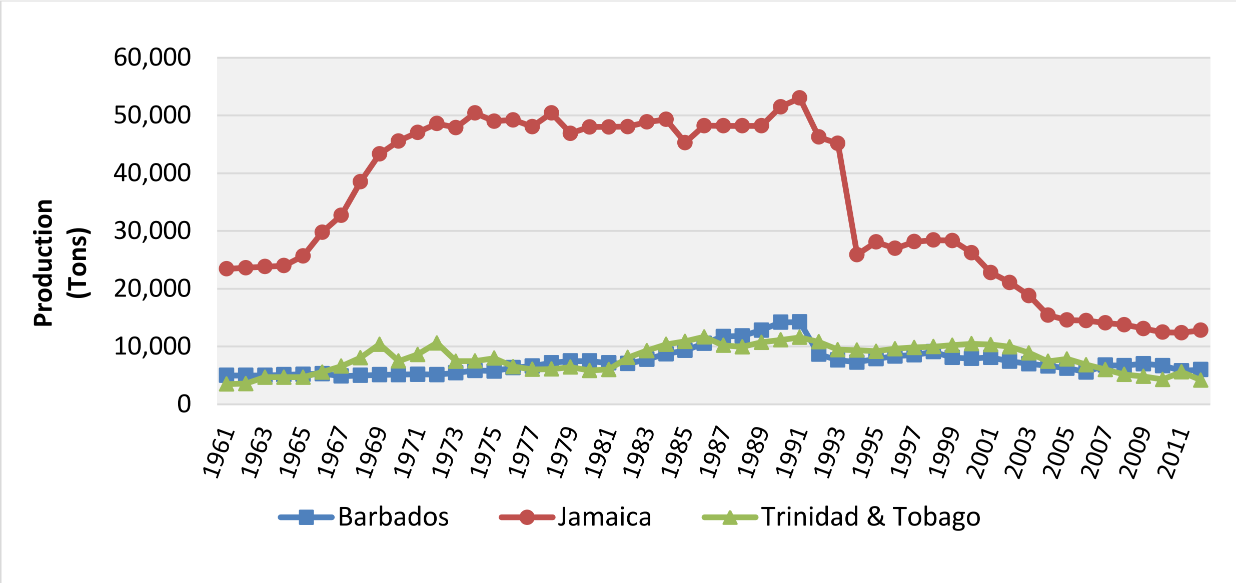

Figure 1. Milk production in major CARICOM producing states
Source. FAOSTAT 2015

Trinidad and Tobago's milk production also declined after reaching a high point of 11,578 tons in 1991. There was a short revival of production from 1999 to 2001, but thereafter production declined steadily reaching to 5,098 tons by 2013. In the late 1980's to early 1990's, according to Singh, Rankine and Seepersad (2005), Trinidad and Tobago was one of the CARICOM countries seeking external financial assistance and implementing a Structural Adjustment Program (SAP). The SAP policy measures included the liberalization of domestic markets including the removal of non-tariff barriers followed by the progressive reduction in the level of tariffs and the reduction of agricultural subsidies with the intention of eventually eliminating them. Thus many of the policy requirements for membership of the WTO were already in place in 1995. On joining the WTO in 1995, Trinidad and Tobago implemented a four-phase schedule of tariff reductions between January 1, 1995 and July 1998 which resulted in the abolition of the import surcharge of 20% on liquid milk at the beginning of 1998 and by 2002, the average Most Favored Nation (MFN) tariff for dairy products was 20.2%, with a tariff of 40% on fresh milk and a tariff of 5% on powdered milk (Singh, Rankine and Seepersad 2005).

Domestic production of milk in Barbados has shown a similar trend. After reaching a high point in production of 14,253 tons in 1991, production fell sharply to 8656 tons in 1992 and since then it has fallen slowly but persistently to reach 6200 by 2013. However the slower rate of fall has meant that domestic milk production in Barbados has exceeded the level of domestic milk production in Trinidad and Tobago since 2007.

Kellman (2012) reports that the dairy industry in Barbados is under stress, in spite of the relatively more stable performance of the industry over the period under review. She states that (as already noted above) the Government reduced its role in the industry during the 1990's SAP and a quota system took effect for dairy farmers (Kellman 2012). By the end of 2010, she states "16 commercial dairy farmers remained in the industry—less than half of the thirty-seven registered farmers in 1990" (Kellman 2012). She also suggests that it is unlikely that milk-based imports had been responsible for the sharp drop in milk production in 1992; instead she states that "the evidence suggests that trade liberalization is exerting pressure on the local industry" (Kellman 2012). She stated finally that her questionnaire-based responses identified several structural defects in the dairy industry which may have also contributed to the decline in milk production including: high farm-level costs of production; high input prices, reproductive and management issues, a paucity of industry support services and the absence of both industry-specific research and independent quality control (Kellman 2012).

Viability of Domestic Production

Figure 2 shows the ratio of 'domestic fresh milk production' to 'total milk supply' for the major CARICOM producing states, where the 'total milk supply' is the sum of 'domestic fresh milk production' plus 'total milk imports in terms of fresh milk equivalents'.[3] This Figure indicates that domestic fresh milk production remains a very important source of total milk supply for Jamaica and Barbados but has shown declining importance in Trinidad and Tobago. For Jamaica domestic fresh milk production provided almost all of the total milk supply for the period 1961-1963, falling to 63% of total milk supply by 1970. From 1977 it remained above 80% until 1990, when there was a precipitous fall to 48% in 1991, reaching a low 32% in 1997. There was a brief recovery to 67% in 1999 but thereafter it remained below 60% until 2011, with an all-time low of 26% in 2004.

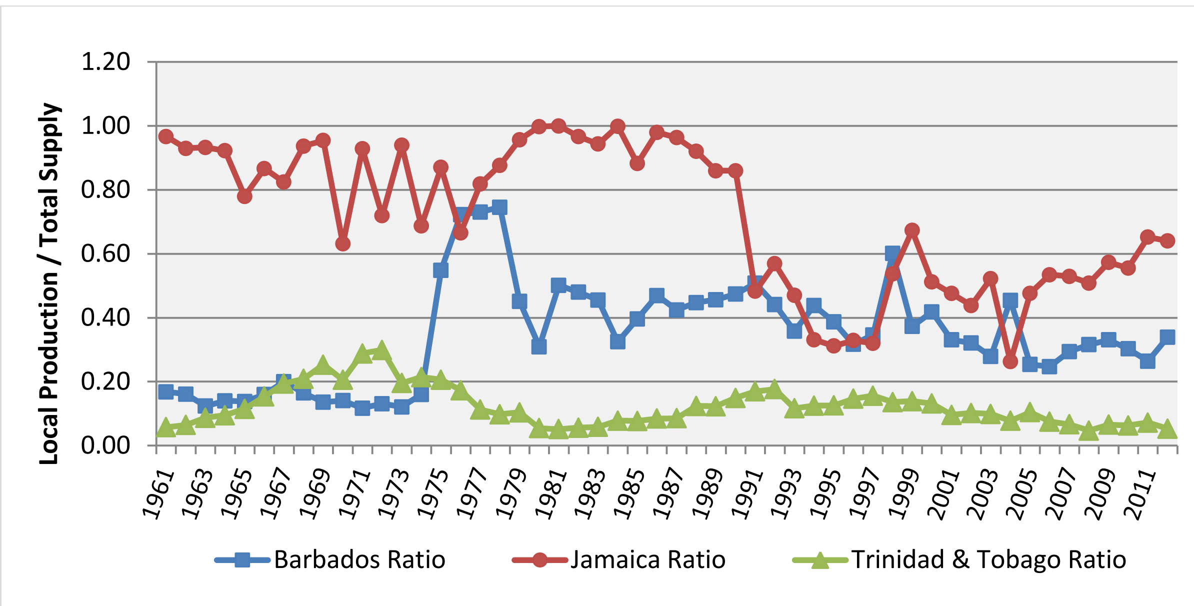

Figure 2. Ratio of local production to total milk supply for major CARICOM producing states
Source. FAOSTAT 2015

For Barbados, domestic fresh milk production provided below 20% of the total milk supply until 1974 and increased rapidly to 75% in 1978, with a rapid fall to 31% in 1980 and thereafter it has fluctuated between 30% and 50% until 1997. An increase of the percentage contribution of

[3] The equivalents to whole fresh milk utilize the International Livestock Research Institute (ILRI) standards: Evaporated and Condensed milk - 6.6 and powdered milk - 7.6 milk equivalents. (International Livestock Research Institute).

domestic fresh milk production (60% in 1998) did follow the purchase by Banks Holding Limited of the BDIL in 1997. However this contribution had again fallen below 40% by 1999 and it has remained below 46% thereafter. For Trinidad and Tobago the domestic fresh milk production reached a high of 30% of the total milk supply in 1972 and thereafter it has remained below 20% to 2012.

Imports

Figure 3 provides the imports of milk products into the three major CARICOM states in milk equivalents. The major importer of milk products has been Trinidad and Tobago. For this country in Figure 3, the increased levels of imports after 1976 are due *inter alia* to both the inclusion of whole dried milk imports after 1979 and the very large imports of evaporated milk between 1982 and 1989. The plot for Jamaica shows a low level of milk imports before 1969 and fluctuating levels of imports between 1970 and 1977 and substantially lower imports thereafter until 1990. From 1991 there was a very large increase in milk imports corresponding to the fall-off in domestic production discussed above, with importation again falling rapidly after 2004. A possible reason for the rapid falloff in the milk imports after 2004 is the rapid rise in the price of imported whole dried milk into CARICOM from that year as shown in Figure 4. Miller, Ffrench, Duffus and Jennings (2007) suggest that this rapid price rise was "triggered by changing consumption patterns in the emerging economies of China and South Asia".

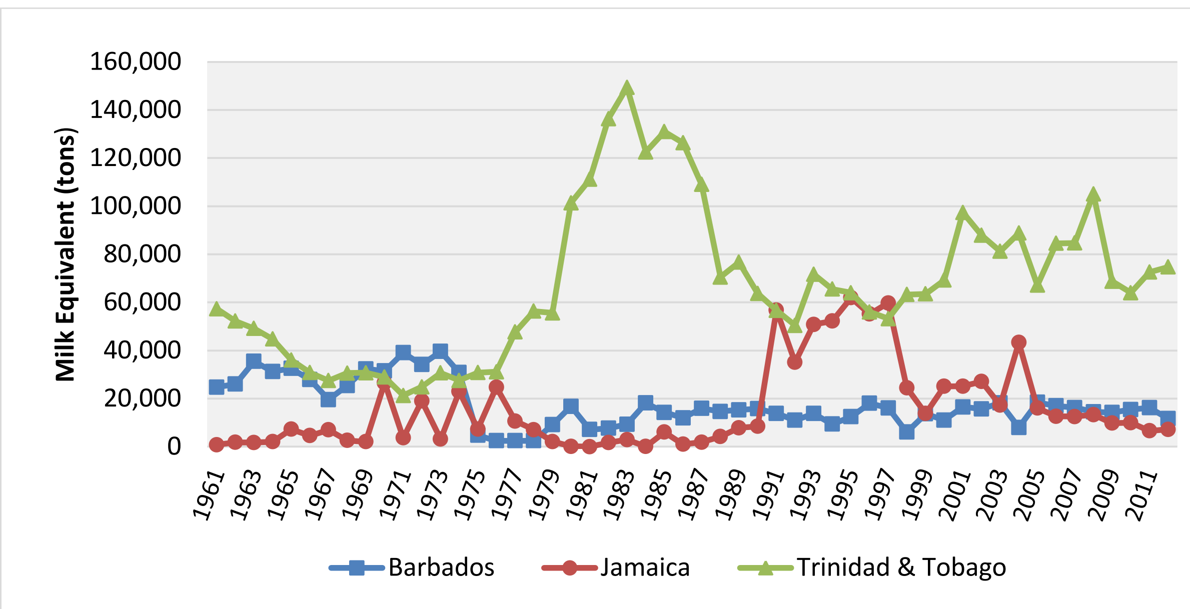

Figure 3. Milk imports into major CARICOM producing states
Note. The data for whole dried milk imports before 1979 was not available for Trinidad and Tobago.
Source. FAOSTAT (2015)

For Barbados in Figure 3, the level of imports fell after a peak level around 40,000 tons in 1973 and has been consistently below 20,000 tons thereafter. Imports fell after 2005, perhaps in response to the rapid rise in the prices of these imports after 2004 (see Figure 4). Also shown in Figure 4, whole dried milk imports, a relatively inexpensive product in 1961 at \$1.06/kg peaked at \$4.94/kg by 2008. The price was still \$4.61/kg in 2012. Similarly, whole evaporated milk prices moved from \$0.36/kg in 1961 to peak at \$2.31/kg in 1990. There was a steep drop off in prices to $0.75 in 1992 and thereafter the price has fluctuated between $0.61/kg and $1.70/kg up until 2012.

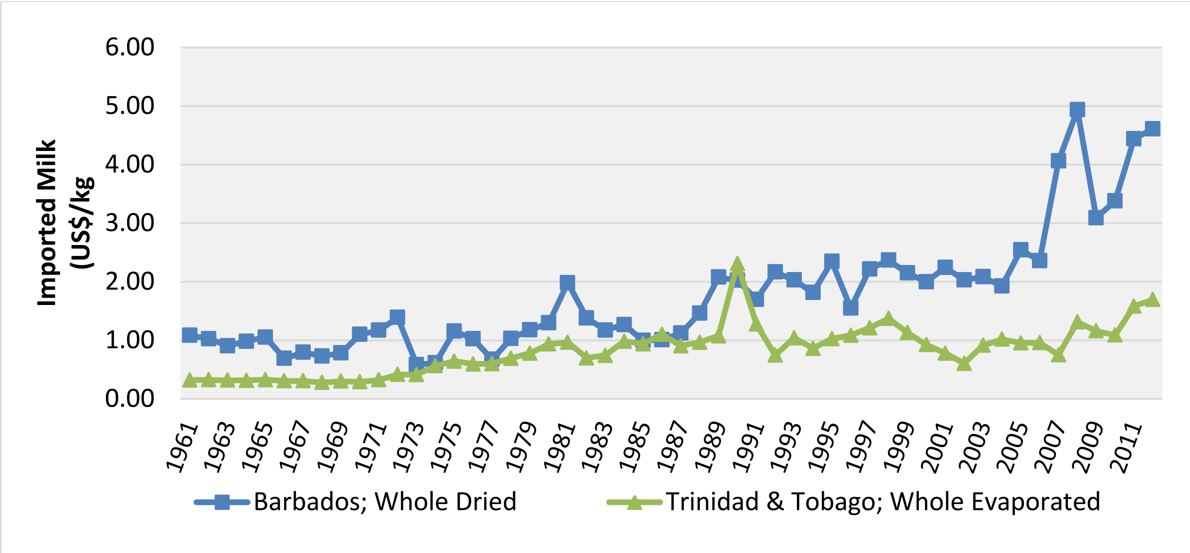

Figure 4. Average prices of selected milk imports into major CARICOM producing states
Source. FAOSTAT (2015)

Figure 5 gives an indication of the GDP per capita (current US $) for the three CARICOM states over the period 1961 to 2012, which indicates that all the countries have been experiencing an upward trend in GDP per capita. Trinidad and Tobago's petroleum based economy has shown a more erratic growth pattern over the period with high economic growth exhibited between 1977 and 1982 and 2002 to 2008 corresponding to periods of high oil prices.

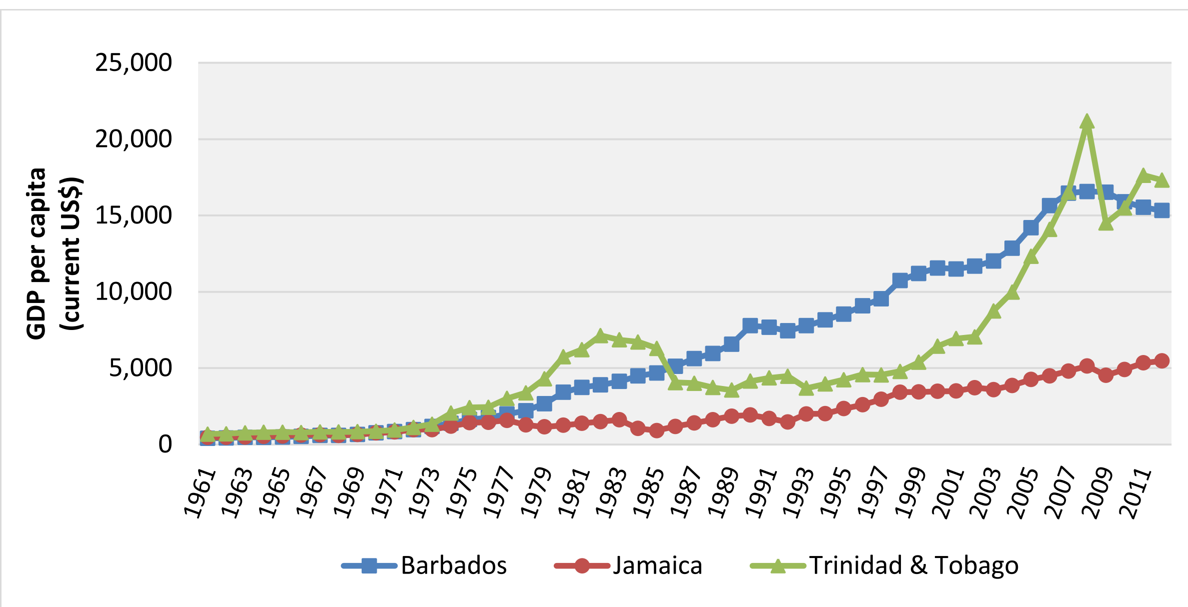

Figure 5. GDP per capita in current $ USD of major CARICOM producing states
Source. The World Bank (2015)

Gerosa and Skoet (2012) in an analysis of 100 middle to low income countries report that the income elasticity of demand for dairy products is positive (>0.72) so they conclude that increases in per capita income (or GDP per capita) lead to increased demand for dairy (and other livestock) products. OECD/FAO (2013) state that the demand for dairy products in developing countries in terms of milk equivalents is expected to grow at an average rate of two percent per annum because of inter alia "robust income growth". Hence for the three CARICOM countries increased GDP per capita could have been a factor causing increased demand for dairy products and hence increased dairy imports, with declining domestic fresh milk production in these countries.

Recent data for CARICOM on imports are available on the CARICOM Secretariat's Tradsys Online platform which allows access to the Regional Trade Information System (CARICOM Secretariat 2015). However, the data base only allows access to the SITC division and aggregate figures for "Dairy Products and Eggs". Utilizing this source, the principal sources of imports of dairy products and eggs into CARICOM are given in Figures 6 and 7. Figure 6 shows that the United States is the major exporter to CARICOM in this commodity code, although given the strong trade links between CARICOM and the United States in the poultry industry, these exports may consist of a substantial volume of hatching eggs. The next largest exporter to the Caribbean is New Zealand and these exports are likely to be almost exclusively dairy products as is the case of the next largest exporter the Netherlands. New Zealand and the European Union (EU) are the world's largest exporters of dairy products (Dairy Australia and FAO 2013). Figure 7 gives the next three largest exporters of dairy products and eggs to CARICOM which are the EU countries of Ireland and the UK (which again are almost exclusively dairy products) and also Mexico.

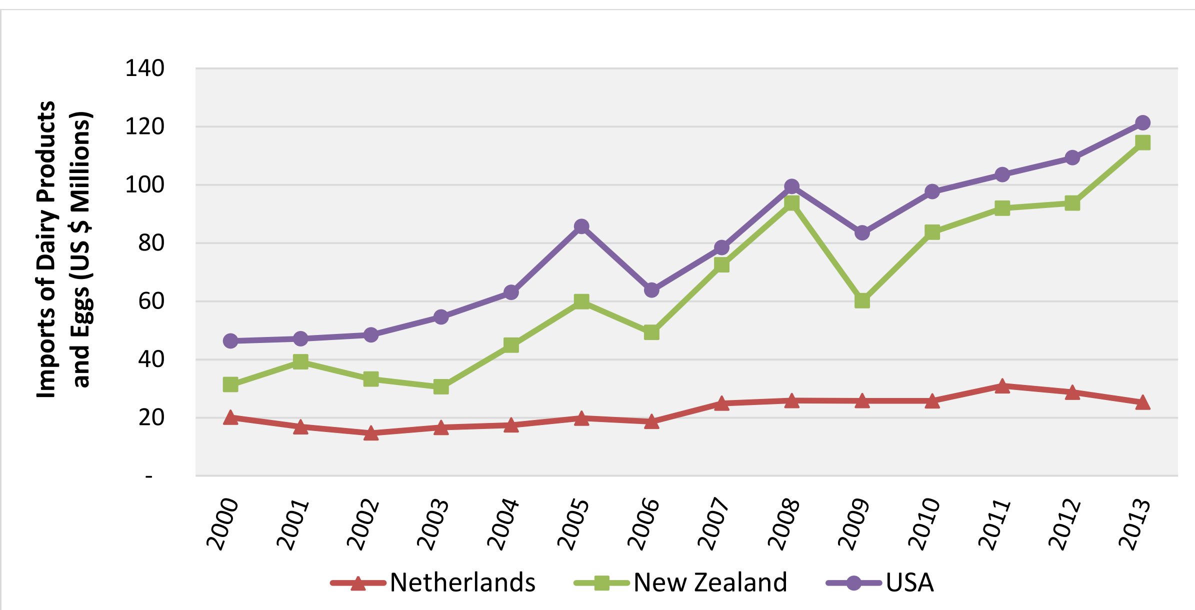

Figure 6. Three major sources of dairy products and eggs imports into major CARICOM producing states
Source. CARICOM Secretariat (2015).

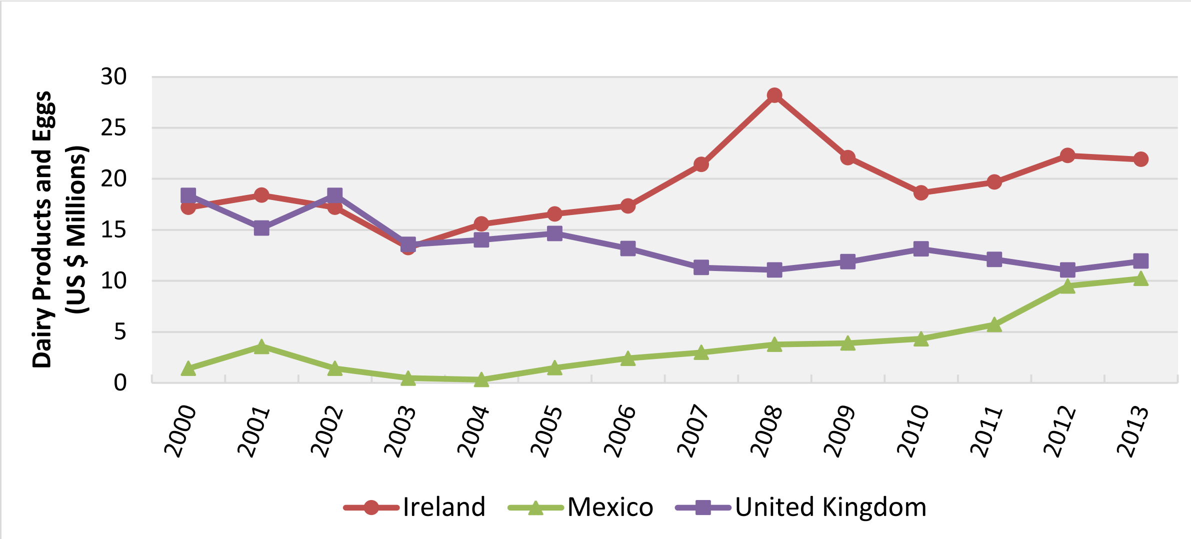

Figure 7. Next three major sources of dairy products and eggs imports into major CARICOM producing states

Source. CARICOM Secretariat (2015)

Analytical Framework

The analysis in this study is based on tracing the changes in the domestic production as well as the level of imports (target variables) over time for milk for the three major CARICOM dairy producers, Jamaica, Trinidad and Tobago and Barbados and performing a determination of the causality of these changes. Since the domestic production and imports are likely to exhibit time trends, the data series for these variables are likely to be non-stationary, ruling out the direct application of ordinary least squares in simple explanatory models, because of the likelihood of spurious correlation (Buck 1999).

The study therefore determines whether other time series of variables associated with trade Granger-cause the target data series - domestic milk production and milk imports. Economic logic and the discussion from the literature of possible determinants of the changes in these data series given above suggest the possible causal variables for the target variables. Thus the following variables are hypothesized to Granger-cause the time series on milk imports: the GDP per capita representing the purchasing power of domestic consumers; the price of these milk imports; as well as the price of domestic milk if domestic milk is an effective competitor for imported milk products. The variables associated with trade that are hypothesized to Granger-cause the data series for domestic milk production are: the price of domestic milk, the level of importation of milk and the GDP per capita, if increasing household incomes cause dairy farmers to seek non-agricultural occupations.

VAR models are utilized in the study. As an example given three different time series variables, denoted by y_{1t} , y_{2t} and x_t where y_{1t} and y_{2t} are endogenous variables and x_t is an exogenous variable, where all the variables are assumed to be stationary, the VAR model of order 1 can be denoted as follows (Hendry and Juselius n.d; Viegi 2010):

1) $y_{1t} = \alpha_1 + \phi_{11} y_{1t-1} + \phi_{12} y_{2t-1} + \phi_{13} x_t + \phi_{14} x_{t-1} + w_{1t}$

2) $y_{2t} = \alpha_2 + \phi_{21} y_{1t-1} + \phi_{22} y_{2t-1} + \phi_{23} x_t + \phi_{24} x_{t-1} + w_{2t}$

Because of the presence of the exogenous variable, this model is sometimes referred to as a VARX (1) model (Bierens, 2004). Each endogenous variable is a linear function of the lagged values for all endogenous variables in the set and the exogenous variable, appropriately lagged.

The error terms or structural shocks, w_{1t} and w_{2t} are white noise innovations with standard deviations σ_{wt1} and σ_{wt2} and a zero covariance. Structural shock w_{1t} affects y_{1t} directly and y_{2t} indirectly.

Information Criteria (IC) such as the Akaike (AIC), Bayesian-Schwartz (BIC) etc. are used to choose the most appropriate number of lags in a VARX(p) model that minimizes the $IC(p)$ for $p = 1, \ldots, P$. Given the lag length (assumed to be 1 in equations 1) and 2) above) then estimates of the equations are obtained by Ordinary Least Squares. Granger-causal hypothesis tests are carried out using the appropriate F-statistic with the null hypothesis:

H_0: $\phi_{13} = \phi_{14} = 0$ (*To test, for example, the hypothesis that* x_t *does not Granger-cause* y_{1t}) and with the alternative hypothesis:

H_a: *any of* ϕ_{13}, ϕ_{14} *not equal to zero.*

P-values for the F-statistic are obtained from AustVet (2016).

The determination of the impact of trade liberalization on milk production and imports in the three target countries focuses on whether this impact coincided with membership in the WTO in 1995, or preceded it in the SAPs that the countries initiated prior to WTO membership. Two alternative approaches can be used to assess this impact of trade liberalization. The first alternative is the performance of Chow tests which involve running two regression models for the two periods created by the break point (pre and post – trade liberalization) and the regression equation for the entire data period and carrying out the test of the hypothesis of no structural break using the appropriate F-statistic. This approach has the advantage of detecting structural changes caused by adjustments to both tariff and non-tariff barriers in trade liberalization in the dairy and related markets in these countries. An alternative approach is to include the ‘tariff rates on milk imports’ and ‘the level of country foreign exchange reserves’ over the study period, as variables in the VARX. However this latter alternative approach is limited to a consideration of only tariff barriers and also could not be used in this study over its data period, as Barbados did not achieve its independence until 1966 and therefore tariff data for this country are not available prior to that year. This issue for Barbados, also precluded the use of time series for the ‘level of foreign exchange reserves’ as another possible variable to Granger-cause the time series on dairy imports, besides which, this variable only provides an indirect indication of trade liberalization.

Chow tests are therefore carried out in this study because of their advantage and the limitations of the alternative approach. To test whether structural changes in the dairy markets could be detected because of membership of the WTO in 1995, for the three target countries, a break point of 1994 is used (pre and post–WTO). To determine whether structural changes because of trade liberalization preceded membership in the WTO, earlier break points are chosen based on the evidence provided in the literature reviewed, and an examination of Figures 1 to 3 above, as follows: Jamaica –1990, Barbados –1991, and Trinidad and Tobago –1992.

Augmented Dickey-Fuller stationarity tests of the data for the three countries found that the time series are non-stationary and $I(1)$. However these time series fail the Engle-Granger tests for co-integration (residuals of the co-integrating regression are non-stationary or the unit-root hypothesis is not rejected). The time series are therefore transformed using an alternative to differencing in the form of the natural logarithm of the ratio of the two levels (*log difference*) to generate the continuously compounded rate of return r (McGowan and Ibrahim 2012). However for low values of r the log difference is almost equal to the percentage change (Hamilton 2014). Thus this nomenclature "percentage change" is adopted to facilitate the explanation of the results of the VARX estimation.

Data series on local farm milk prices are inadequate for the purposes of this study. Therefore the variables for the VARX analysis carried out, based on equations 1) and 2) are the *log differences* for the period **1961** to **2012** as follows:[4]

y_{1tk} = **Milkprod** = Annual milk production in Country k (Trinidad and Tobago, Barbados and Jamaica)[1]
y_{2tk} = **MilkEqimp** = Annual milk imports in milk equivalents into Country k [1]
With two exogenous variables:

x_{1tk} = **TTgdp or BARgdp or JAMgdp** = GDP per capita in Country k [2]

x_{2tk} = **Evapmilkpr** or **Drymilkpr** = Import Price of the Milk Product in Country k [1]

Source. [1] FAOSTAT 2015; [2] World Bank 2015

All of the transformed series are stationary $I(0)$ using the Engel Granger test. Portmanteau tests, specifically the Ljung-Box (LB) Q-tests are carried out for residual autocorrelation with the null hypothesis being no autocorrelation (Mathworks n.d.). Heteroscedasticity and autocorrelation consistent" (HAC) standard errors are utilized to correct for any residual autocorrelation, and this procedure is most effective in the absence of strongly auto-correlated time series. (Muller 2014). Information criteria tests determined that the appropriate lag length for all the VARX models is one.

Results

Table 1 shows the results for the VARX estimation for Trinidad and Tobago. The LB Q-test shows no significant autocorrelation, which favored the use of HAC standard errors (Muller

[4] The sources of the data for the variables are provided below the variables.

2014). No variable is significant in the equation for the percentage change in Milk Production. For the percentage change in Milk Imports (in milk equivalents) annual percentage changes in GDP per capita significantly positively Granger-cause the percentage changes in milk imports as evidenced by the significance of the coefficients and the F-test carried out. There is also evidence that lagged higher prices for evaporated milk may have influenced a fall-off in dairy imports (and vice versa) given the significance of lagged price coefficient but this evidence did not extend to Granger causation. There is evidence of a weak and positive Granger causation between Milk Production (lagged) and Milk Imports, but more in the nature of a complementary as opposed to substitute relationship. For Trinidad and Tobago, the Chow tests do not detect any structural change for both milk production and imports because of trade liberalization, prior to or after membership in the WTO in 1995.

Table 2 shows the results for the VARX estimation for Barbados and indicates that the LB Q-test showed the absence of significant autocorrelation. Annual percentage changes in GDP per capita weakly Granger-cause the annual percentage change in Milk Production. For the annual percentage change in Milk Imports (in milk equivalents) annual percentage changes in GDP per capita (lagged) weakly influence the annual percentage changes in milk imports, but this influence does not extend to Granger causation. For Barbados, the Chow tests detect significant structural changes in the time series of both the annual percentage changes in milk production and milk equivalent imports from 1993 (break point 1992), prior to membership in the WTO. The Chow test also detects further significant structural change in the time series for the annual percentage change in milk equivalent imports with membership in the WTO from 1995.

Table 1. VARX Results Trinidad and Tobago

Trinidad and Tobago VAR system, lag order 1
OLS estimates, observations 1963-2012 (T = 50)
Log-likelihood = 43.3969
Determinant of covariance matrix = 0.0006
AIC = -1.1759
BIC = -0.6405
HQC = -0.9720
Portmanteau test: LB(12) = 36.4278, df = 44 [0.7842]

Equation 1: Milkprod
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Constant	0.0089	0.0230	0.3858	0.7015	
Milkprod-1	−0.0531	0.1751	−0.3031	0.7633	
milkEqimp-1	−0.0728	0.0987	−0.7375	0.4648	
TTgdp	−0.0520	0.0907	−0.5734	0.5694	
TTgdp-1	−0.0107	0.1170	−0.0911	0.9278	
Evapmilkpr	0.0064	0.0642	0.0990	0.9216	
Evapmilkpr-1	−0.0368	0.0877	−0.4197	0.6768	

Mean dependent var	0.0030	S.D. dependent var	0.1469
Sum squared resid	1.0359	S.E. of regression	0.1552
R-squared	0.0200	Adjusted R-squared	–0.1167
F(6, 43)	0.1736	P-value(F)	0.9825
rho	–0.0077	Durbin-Watson	1.8833

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 43)	=	0.0919 [0.7633]
All lags of MilkEqimp	F(1, 43)	=	0.5439 [0.4648]
All lags of TTgdp	F(2, 45)	=	0.0632 [0.9388]
CHOW Test: break point at 1994	F(7, 35)	=	0.5718 [0.7737]
CHOW Test: break point at 1992	F(7, 35)	=	1.0140 [0.4385]

Equation 2: MilkEqimp
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Constant	−0.0428	0.0280	−1.5258	0.1344	
Milkprod-1	0.3518	0.1871	1.8799	0.0669	*
MilkEqimp-1	−0.0564	0.0792	−0.7124	0.4801	
TTgdp	0.4053	0.2161	1.8754	0.0675	*
TTgdp-1	0.3791	0.1363	2.7802	0.0080	***
Evapmilkpr	0.0404	0.1006	0.4016	0.6900	
Evapmilkpr-1	−0.1616	0.0721	−2.2431	0.0301	**

Mean dependent var	0.0072	S.D. dependent var	0.2001
Sum squared resid	1.4819	S.E. of regression	0.1856
R-squared	0.2448	Adjusted R-squared	0.1394
F(6, 43)	4.0028	P-value(F)	0.0029
rho	−0.0436	Durbin-Watson	2.0832

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 43)	=	3.534* [0.0669]
All lags of MilkEqimp	F(1, 43)	=	0.50748 [0.4801]
All lags of TTgdp	F(2, 45)	=	5.3087*** [0.0085]
All lags of Evapmilkpr	F(2, 45)	=	1.228 [0.3025]
CHOW Test: break point at 1994	F(7, 35)	=	0.3379 [0.931]
CHOW Test: break point at 1992	F(7, 35)	=	1.056 [0.4116]

Table 2. VARX Results Barbados

Barbados VAR system, lag order 1	AIC = -0.0718
OLS estimates, observations 1963-2012 (T = 50)	BIC = 0.4635
Log-likelihood = 15.7959	HQC = 0.1320
Determinant of covariance matrix = 0.0018	Portmanteau test: LB(12) = 55.242, df = 44 [0.1192]

Equation 1: Milkprod

HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
constant	−0.0366	0.0340	−1.0760	0.2879	
Milkprod-1	0.1465	0.0939	1.5604	0.1260	
MilkEqimp-1	−0.0206	0.0207	−0.9941	0.3257	
BARgdp	0.4120	0.2146	1.9203	0.0615	*
BARgdp-1	0.1528	0.2162	0.7069	0.4834	
Drymilkpr	−0.0338	0.0458	−0.7370	0.4651	
Drymilkpr-1	−0.0066	0.0349	−0.1881	0.8517	

Mean dependent var	0.0036	S.D. dependent var	0.1010
Sum squared resid	0.4223	S.E. of regression	0.0991
R-squared	0.1549	Adjusted R-squared	0.0370
F(6, 43)	1.7941	P-value(F)	0.1230
rho	0.0423	Durbin-Watson	1.8915

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 43)	= 2.4348 [0.1260]
All lags of MilkEqimp	F(1, 43)	= 0.9882 [0.3257]
All lags of BARgdp	F(2, 45)	= 2.493* [0.094]
CHOW Test: break point at 1994	F(7, 35)	= 0.5879 [0.7611]
CHOW Test: break point at 1991	F(7, 35)	= 7.224*** [<0.0001]

Equation 2: MilkEqimp

HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
constant	0.0414	0.0783	0.5285	0.5999	
Milkprod-1	0.3042	0.3354	0.9069	0.3695	
MilkEqimp-1	−0.0336	0.1871	−0.1797	0.8582	
BARgdp	1.4863	1.6356	0.9087	0.3686	
BARgdp-1	−2.1258	1.2014	−1.7695	0.0839	*
Drymilkpr	−0.2917	0.2875	−1.0145	0.3160	
Drymilkpr-1	−0.0555	0.2236	−0.2482	0.8051	

Mean dependent var	−0.0159	S.D. dependent var	0.4918
Sum squared resid	10.8276	S.E. of regression	0.5018
R-squared	0.0864	Adjusted R-squared	–0.0410
F(6, 43)	1.7612	P-value(F)	0.1301
rho	−0.0361	Durbin-Watson	2.0601

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 43)	= 0.8225 [0.3695]
All lags of MilkEqimp	F(1, 43)	= 0.0323 [0.8582]
All lags of BARgdp	F(2, 45)	= 1.2125 [0.307]
CHOW Test: break point at 1994	F(7, 35)	= 2.3391** [0.0454]
CHOW Test: break point at 1991	F(7, 35)	= 2.377** [0.0425]

Table 3 shows the results for the VARX estimation for Jamaica. The LB Q-test again shows the absence of significant autocorrelation. No variable is significant in the equation for the percentage change in Milk Production. For the percentage change in Milk Imports (in milk equivalents) there are two instances of significant exogenous Granger-causation: the annual percentage changes in GDP per capita as well as the annual percentage in the Price of Whole Dry Milk evidenced by the significant F-Tests and coefficients. The lagged percentage change in Milk Imports also significantly Granger-influences the current level of Milk Imports. For Jamaica the Chow tests detect significant structural changes in the time series of both the annual percentage changes in milk production and milk equivalent imports from 1991 (break point 1990) four years prior to membership in the WTO. No further structural change in both time series is detected by the Chow tests after membership of the WTO in 1995.

Table 3. VAR Results Jamaica

Jamaica VAR system, lag order 1	AIC = 1.4247
OLS estimates, observations 1963-2009 (T = 47)	BIC = 1.9759
Log-likelihood = -19.4816	HQC = 1.6321
Determinant of covariance matrix = 0.0078	Portmanteau test: LB(11) = 52.4829, df = 40 [0.0893]

Equation 1: Milkprod
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
constant	−0.0118	0.0167	−0.7092	0.4823
Milkprod-1	0.2075	0.2036	1.0191	0.3143
MilkEqimp-1	0.0050	0.0139	0.3615	0.7197
Drymilkpr	−0.0028	0.0378	−0.0746	0.9409
Drymilkpr-1	0.0179	0.0379	0.4714	0.6399
JAMgdp	0.1412	0.0947	1.4911	0.1438
JAMgdp-1	−0.1226	0.2476	−0.4951	0.6232

Mean dependent var	−0.0130	S.D. dependent var	0.1067
Sum squared resid	0.4897	S.E. of regression	0.1107
R-squared	0.0642	Adjusted R-squared	-0.0761
F(6, 40)	0.5773	P-value(F)	0.7461
rho	−0.0271	Durbin-Watson	2.0474

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 40)	=	1.0386 [0.3143]
All lags of MilkEqimp	F(1, 40)	=	0.131 [0.7197]
All lags of JAMgdp	F(2, 42)	=	0.7060 [0.4994]
All lags of Drymilkpr	F(2, 42)	=	0.0620 [0.9400]
CHOW Test: break point at 1994	F(7, 32)	=	1.514 [0.198]
CHOW Test: break point at 1990	F(7, 32)	=	3.234** [0.0104]

Table 3. VAR Results Jamaica- *Continued*

Equation 2: MilkEqimp
HAC standard errors, bandwidth 2 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
constant	−0.1167	0.1918	−0.6084	0.5464	
Milkprod-1	0.6866	0.7629	0.9000	0.3735	
MilkEqimp-1	−0.6103	0.1161	−5.2554	<0.0001	***
BARgdp	−1.1316	0.3629	−3.1180	0.0034	***
BARgdp-1	−0.8009	0.4309	−1.8588	0.0704	*
Drymilkpr	3.2715	1.1400	2.8696	0.0065	***
Drymilkpr-1	1.3825	1.4334	0.9645	0.3406	

Mean dependent var	0.0296	S.D. dependent var	1.3304
Sum squared resid	35.7454	S.E. of regression	0.9453
R-squared	0.5610	Adjusted R-squared	0.4951
F(6, 40)	20.0316	P-value(F)	1.19e-10
rho	−0.0623	Durbin-Watson	2.1202

F-tests of Zero Restrictions:

All lags of Milkprod	F(1, 40)	= 0.80997 [0.3735]
All lags of MilkEqimp	F(1, 40)	= 27.619*** [<0.0001]
All lags of JAMgdp	F(2, 42)	= 4.5871** [0.0158]
All lags of Drymilkpr	F(2, 42)	= 3.7209** [0.0325]
CHOW Test: break point at 1994	F(7, 32)	= 1.238 [0.3116]
CHOW Test: break point at 1990	F(7, 32)	= 2.929** [0.0174]

Conclusions and Implications

Malcolm (1999) suggests that the Uruguay Round of GATT and its implementation through countries attaining membership of the WTO would have had a major impact on dairy industries in developing countries through increased access to their markets, which had previously been protected by restricting imports through tariff and non-tariff measures. There was a lot of anecdotal evidence of such an impact of the WTO Uruguay Round measures on the dairy industries of the Caribbean. This was not demonstrated in this study except for the case of milk imports into Barbados, where the study was able to detect a structural change in the annual percentage changes in milk imports after membership in the WTO in 1995. For Barbados and Jamaica however the impact of trade liberalization on both milk production and imports has been detected pre-1995 most likely caused by the various SAPs that had been implemented in those CARICOM states. For Jamaica the changes are detected from 1991 and for Barbados from 1992. No impact of trade liberalization has been detected for Trinidad and Tobago perhaps reflecting the minor contribution of domestic milk production to total milk supply in that state as opposed to Barbados and especially Jamaica.

The study exposes the pattern of dairy imports into the Caribbean and the dominant role played by New Zealand and the EU, the major two players on the international dairy export market. The study also demonstrates that the percentage change in milk imports for the CARICOM states is highly influenced by the percentage change in GDP per capita. For Jamaica the percentage change in milk imports is also highly influenced by the annual percentage in the price of whole dry milk and for Trinidad and Tobago there is a weak influence of evaporated milk price on milk imports. Thus for the three CARICOM states, increased imported milk products are associated with increased household incomes, in addition to trade liberalization. Indeed the results of this study provide support to the conclusions of Kellman (2012) that it was unlikely that increased importation of milk products *alone* was responsible for the sharp drop in domestic milk production in the three main CARICOM producers after 1991. Non-trade factors are probably more influential for Trinidad and Tobago where no trade liberalization effects have been detected in this study. Therefore the study recommends research into the structural defects of the CARICOM dairy industry as other possible causal factors of declining production levels including: high farm-level costs of production; high input price levels, reproductive and management issues concerning cattle production, a paucity of industry support services and the absence of industry-specific research as suggested by Kellman (2012).

This paper has important implications for milk trade and production in the Caribbean. For Barbados and Jamaica, trade liberalization by the various SAPs had a significant impact in increasing milk imports—the competition influenced a reduction in domestic milk production, which itself was suffering from a number of deficiencies just noted. To prevent such future disruptions to the CARICOM agricultural sector including the dairy industry, the decisions of the Tenth Ministerial Conference in Nairobi on the Special Safeguard Mechanism (SSM) for Developing Countries could be crucial (WTO 2016). This mechanism would allow developing countries to temporarily increase tariffs on agricultural products in cases of import surges or price declines (WTO 2016). If such a mechanism had existed it may have been invoked to provide some relief to the crisis created in the CARICOM milk industry with trade liberalization in the 1990s.

Many CARICOM countries still experience foreign exchange shortages and restrictions. A major area of foreign exchange outflows is in the importation of dairy products. The results of this paper have shown very persistent downward trends in domestic milk production in these Caribbean states that may be very difficult to reverse. With the very significant relationship between per capita GDP and milk importation, economic problems lowering the per capita GDP of these countries can therefore cause a sharp fall-off in milk demand and importation, which may have severe impacts on the levels of food security of these countries, especially Jamaica.

The paper also demonstrates that the two countries influenced by the large multi-national firm *Nestle* show a greater fall-off in milk production since 1990 than Barbados, where the industry is coordinated by a locally owned firm Barbados Dairy Industries Limited. This situation has led to Barbados producing more milk than Trinidad and Tobago in the more recent years since 2007. The presence of this multinational firm thus may not have been of major benefit in recent years to the CARICOM dairy farmers, although the firm is supposed to provide a guaranteed market for farmers' milk. Research is therefore warranted on the contribution of *Nestle* to Caribbean dairy development and the feasibility of alternative dairy policy options for the Caribbean including cooperatives (Anderson et al. 2006; Aneja 1993).

Finally the paper has direct implications for the small milk producers in the Caribbean, many of whom still depend largely on this industry for their livelihood. It is therefore highly recommended that attention be placed on policies to assist in the alleviation of farm level problems noted above, to assist in saving the dairy industry in the Caribbean and the livelihoods of thousands of small scale producers.

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The Role of California and Western US Dairy and Forage Crop Industries in Asian Dairy Markets

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Abstract

California's dairy and the closely linked forage crop industries developed a remarkable record of growth and success until about a decade ago when growth slowed dramatically. California's dairy farms and processing plants still account for about 20% of US milk production and almost 40% of US dairy exports. California alfalfa and other hay account for about 30% of production among states west of the Rocky Mountains. Continued population and income growth is projected to expand the demand for dairy products in Asia. California can play a crucial role in meeting this demand if it can maintain competitiveness in milk production and processing.

Keywords: exports, dairy, forage, alfalfa hay, Asian demand, California

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Introduction

The dairy industry in California and the closely linked forage crop industries grew remarkably for three decades through 2007 after which output has been stagnant (Sumner 2014). California accounts for about 20% of US milk production and almost 40% of US dairy product exports. Milk production is supported by a forage crop industry within California and in other Western states. The seven states west of the Rocky Mountains produce 31.5% of US alfalfa hay (USDA-NASS). The supply of high-quality forage and presence of favorable climatic conditions for maintaining dairy cattle are leading factors in California's and Western US states' ability to supply both processed dairy products and forage inputs to meet expanding dairy demand in Asia.

This article focuses on long-term developments in export markets, but a number of current events and recent developments warrant attention. California was in a historic drought that has lingering consequences despite above normal precipitation for the 2015/16 water year (Howitt et al. 2015). Despite the drought, milk production rose with high milk prices in 2014 and fell by 3% in 2015 as cow numbers fell by about 2% (CDFA 2016). The irrigation situation is one more factor limiting the expansion of dairy supply from California as local hay and silage acreage must compete for water with tree nuts, which have expanded acreage rapidly in recent years. The collapse in tree nut prices in late 2015 and 2016 may put a damper on expansion in tree nut plantings, but as more active markets allow water to be allocated across uses based on potential profitability, forage crops will face stiffer competition.

Dairy policy may change if the California milk marketing order is replaced by a federal order. That proposal awaits USDA response and is likely several years from reality even if it is eventually approved by producers. A potential shift to a federal marketing order has no mechanism for supply control. A different government pricing policy across dairy products could affect the regulated minimum prices for farmers and the distribution of product mix somewhat. This article does not include projections of the impact of changes in the details of the California pricing system.

Other current issues facing California dairy include concerns about access to hired farm labor and environmental regulations on farms and processors. Water quality and air quality issues limit expansion of dairy production in the Central Valley, where most of the dairy industry is located. Potential subsidies for manure handling may add to dairy revenue and allow shifts in manure handling (Lee and Sumner 2014).

This article examines trends in dairy product consumption in Asia and the potential for continued growth in demand into the future. In addition, export data will show the role of dairy products and hay shipped from western ports in supplying Asian markets. We offer data and some ideas about future market developments. The major policy development that may affect trade relations in the region is the Transpacific Partnership (TPP) agreement which has been signed but not ratified or implemented. We do not include analysis of the implications of the TPP here because it excludes major markets (Korea and China for example), and the dairy provisions are small at best (Sumner, Lee and Matthews 2015).

Asian Dairy Market Developments

Growth in dairy consumption in emerging markets depends on growth in population, urbanization, and per capita income. Of course, long-standing historical and cultural factors affect consumption patterns, and these may also evolve slowly over time. For example, at each income level, populations with European heritage or influence have higher, and East Asians have lower, per capita dairy consumption (FAOSTAT 2016).

As the population grows slowly and per capita incomes rise more rapidly, Asian consumption of dairy products is increasing. USDA projects that the demand for processed dairy products is especially likely to expand rapidly in Asian markets (USDA–ERS 2013). Along with cultural shifts, changes in population and income are expected to contribute to changes in demand for dairy products for the region.

Population Growth

Populations are projected to grow among developing countries in Asia and shrink in Japan and Korea over the next fifteen years. Demographic projections use assumptions related to sex ratios and mortality in addition to assumptions about events such as war, famine and natural disasters (US Census 2013).

China, a large destination for US forage and dairy products, projects slight population growth over the next decade, then a gradual leveling off toward 2026 ending the 2020's with a slight decline (Figure 1). With shrinking populations in the wealthy countries of Japan and South Korea, the main area of population growth will almost exclusively be in developing countries such as Malaysia and Philippines, with slightly smaller growth in Indonesia and Vietnam. These high-growth developing countries are not now the main Asian markets for dairy and forage product exports, but between now and 2030 the pending population growth will expand the market potential substantially.

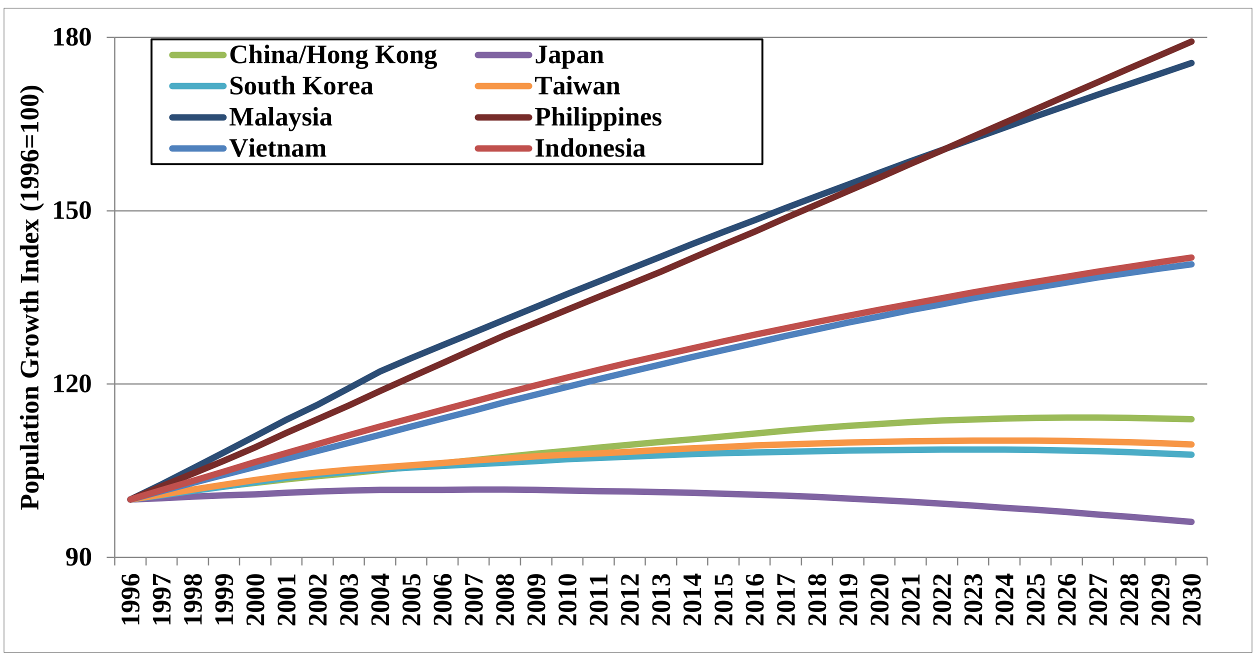

Figure 1. Past, current and projected future population of major Asian destination countries for US forage crop and dairy product exports, 1996–2030.
Source. U.S. Department of Commerce, Census Bureau

Changes in Per Capita Income

For dairy demand, it is especially crucial that many developing countries are reaching income levels at which they demand diet improvement, not just more food. For most people, diet improvement means more consumption of livestock protein products, including dairy products. Along with population, per capita income growth occurred both globally and in Asia over the past couple of decades in many of the large countries of Asia. In spite of declines in the rate of growth in 2015 (World Bank 2015), personal income is expected to keep increasing over the next fifteen years (USDA–ERS) (Table 1).

Table 1. Real per capita GDP by decade (base year = 2005).

Region/Country	1991–2000	2001–2010	2011–2020	2021–2030
World	$6,077	$7,170	$8,311	$10,419
Asia	$2,462	$3,166	$4,484	$6,524
China	$804	$1,936	$4,321	$8,187
Indonesia	$1,045	$1,291	$2,049	$3,173
Malaysia	$4,157	$5,387	$7,247	$10,042
Philippines	$962	$1,158	$1,564	$2,128
Vietnam	$369	$653	$1,099	$1,903

Source. USDA Economic Research Service, International Macroeconomic Data Set.

From 1990 to 2010 China experienced per capita income growth at an annual rate of greater than 9%. With 2005 as the baseline, real per capita income in China was about $715 in 1990 and grew to about $5,661 per capita in 2013. Income in China is expected to continue to grow in the next two decades but at a slower rate (World Bank 2015). In the decade of the 2020's projected per capita income will grow annually at an average of over 6% and decline to a rate of 5% growth per year the following decade. Much of this growth in income is attributed to a large migration of the Chinese population away from the rural countryside toward urban areas where higher paying jobs in manufacturing are found. Increased urban living often leads to adopting a diet more like that of Europe and the United States, again including more dairy consumption.

Although not as dramatic as in China, per capita incomes also increased over the decades in other large Asian countries such as Malaysia, Philippines, and Vietnam. Residents of these countries are projected to continue increasing their incomes from now through 2030 (Figure 2).

The increase in per capita income in Asia since 2000 has coincided with improved diets and increases in the per capita consumption of animal products. Since the mid-1970's per capita consumption in China, Japan, Korea, Malaysia, Philippines, Taiwan and Vietnam, the largest destinations for US forage and dairy exports in the region, has increased among all animal protein sources (Figure 3). The largest increase in consumption of animal-based protein is pork, beef and poultry meat products (UN FAOSTAT).

Dairy consumption increased gradually from the early 1960's to mid-1990's (Figure 4). Since 1997, the rapid expansion of the Chinese economy coincides with a large increase in per capita dairy consumption. The same yet less steady increases occurred in Vietnam. During the 35-year-period from 1960 to 1995, per capita, dairy protein intake in Asia-Pacific increased about one gram. In the sixteen years from 1997 to 2013, per capita dairy protein intake increased by almost two grams.

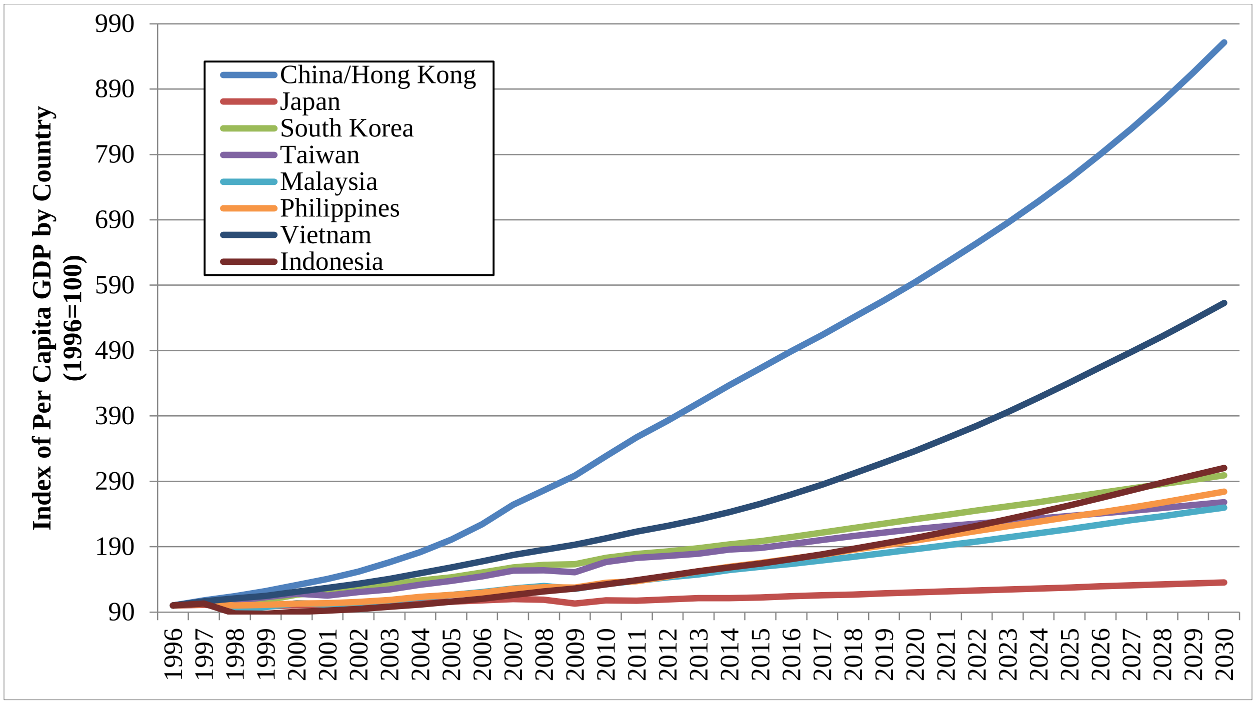

Figure 2. Index of real per capita GDP for major Asian destination countries for US forage and dairy product exports, 1996–2040.

Source: USDA-Economic Research Service, International Macroeconomic Data Set.

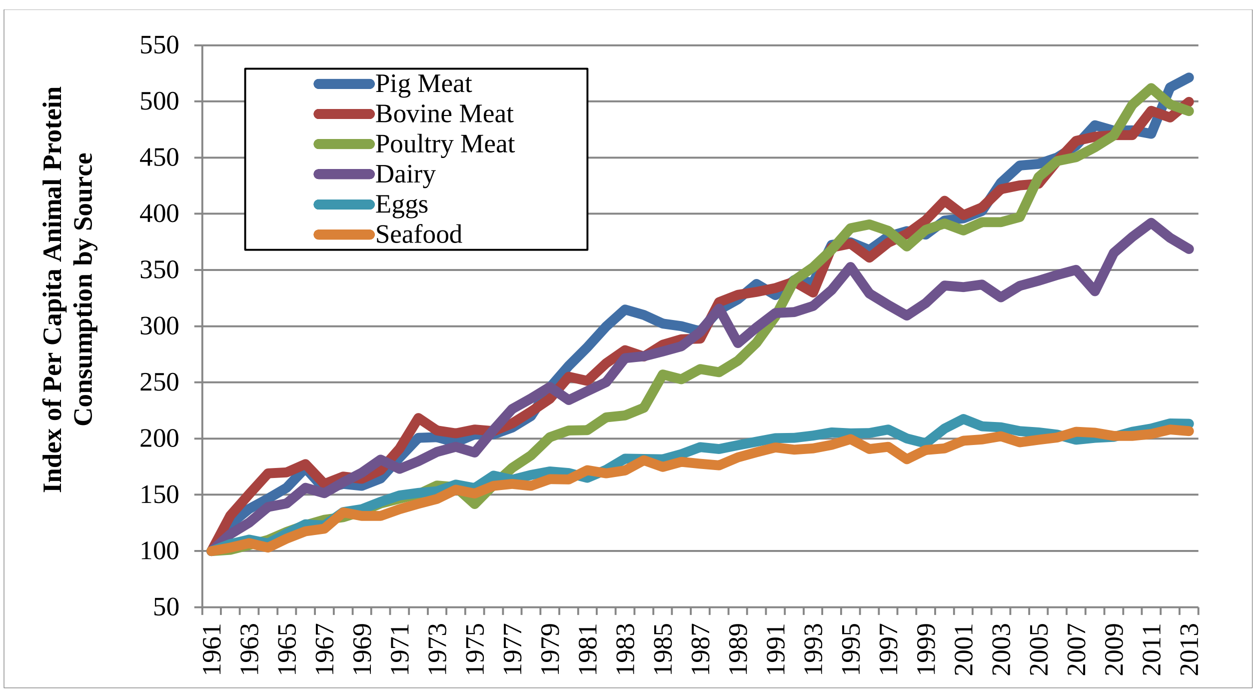

Figure 3. Index of animal protein consumed per capita, per day, by source in major Asian destination countries for US forage and dairy product exports, 1961–2013.

Source. UN FAO Statistical Database

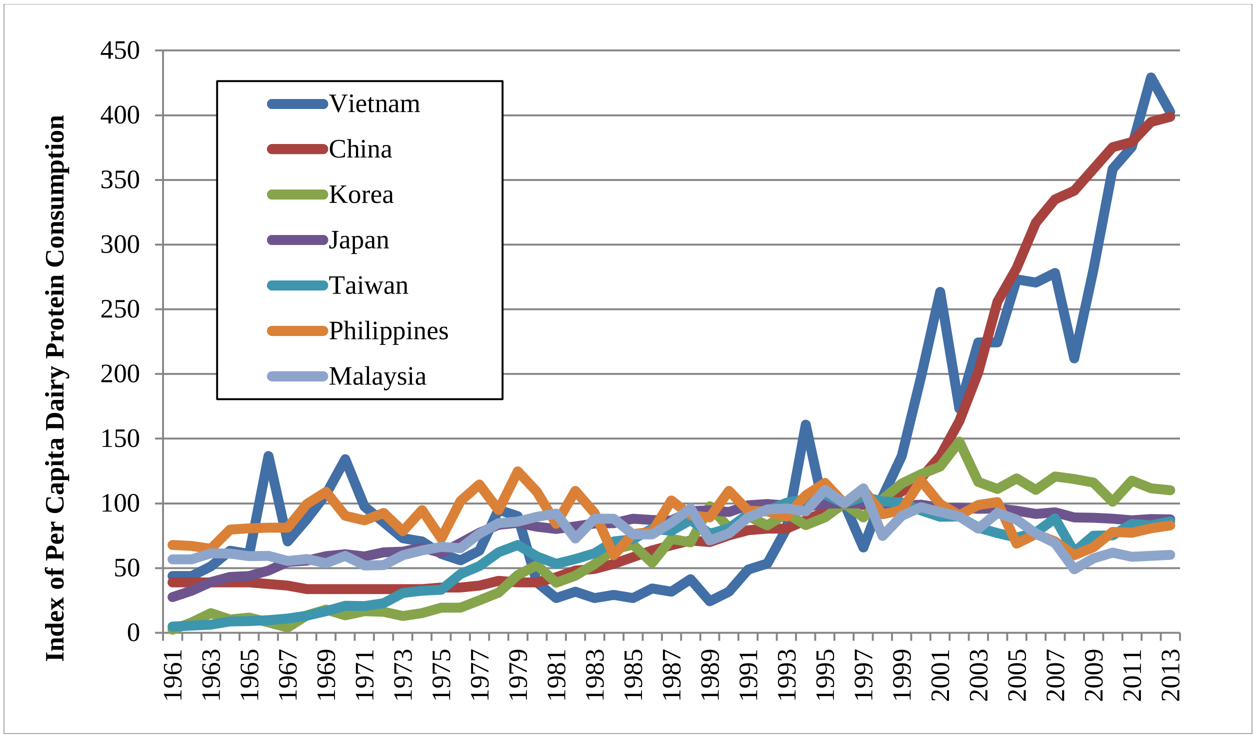

Figure 4. Index of dairy protein consumed per capita, per day in major Asian destination countries for US forage and dairy product exports, 1961–2013 (1996=100).
Source: UN FAO Statistical Database

Western US Agriculture's Role in Meeting Dairy Market Demand in Asia

The rapid expansion in demand for dairy products since the early 2000's is a challenge for China's domestic producers. China has aggressively expanded their domestic dairy herd and domestic milk production, mostly to fulfill fluid milk demand, and there was a dramatic increase in the volume of dairy product imports (Li and Frederick 2015). Examining the China situation demonstrates how the California dairy and Western US forage crop industries can benefit from opportunities presented by growth in dairy demand throughout Asia.

Expansion of Asia/Pacific Domestic Dairy Herd

Aided by government support programs, China has increased the size of the domestic dairy herd from just over 2 million head in 2000 to around 8.5 million head in 2015 (Figure 5). Small farms are exiting making way for larger dairy farms (Li and Frederick 2015).

These changes involve imports of live dairy cattle from locations such as Australia, New Zealand, and Uruguay to improve genetics in China's domestic dairy herd (Li and Frederick 2015). In 2014, over 196,000 head of live dairy cattle were imported. In addition to imported cattle, China's Ministry of Agriculture continues to subsidize an ongoing dairy-breeding program for producers to improve domestic dairy herd breeding stock (Li and Frederick 2015). This subsidy provides semen doses for approximately 8.4 million breeding cows (Li and Frederick 2015). Although improved genetics increased milk productivity slightly, China still lags in yields per cow compared to the leading dairy producing countries (Li and Frederick 2015) (Figure 6).

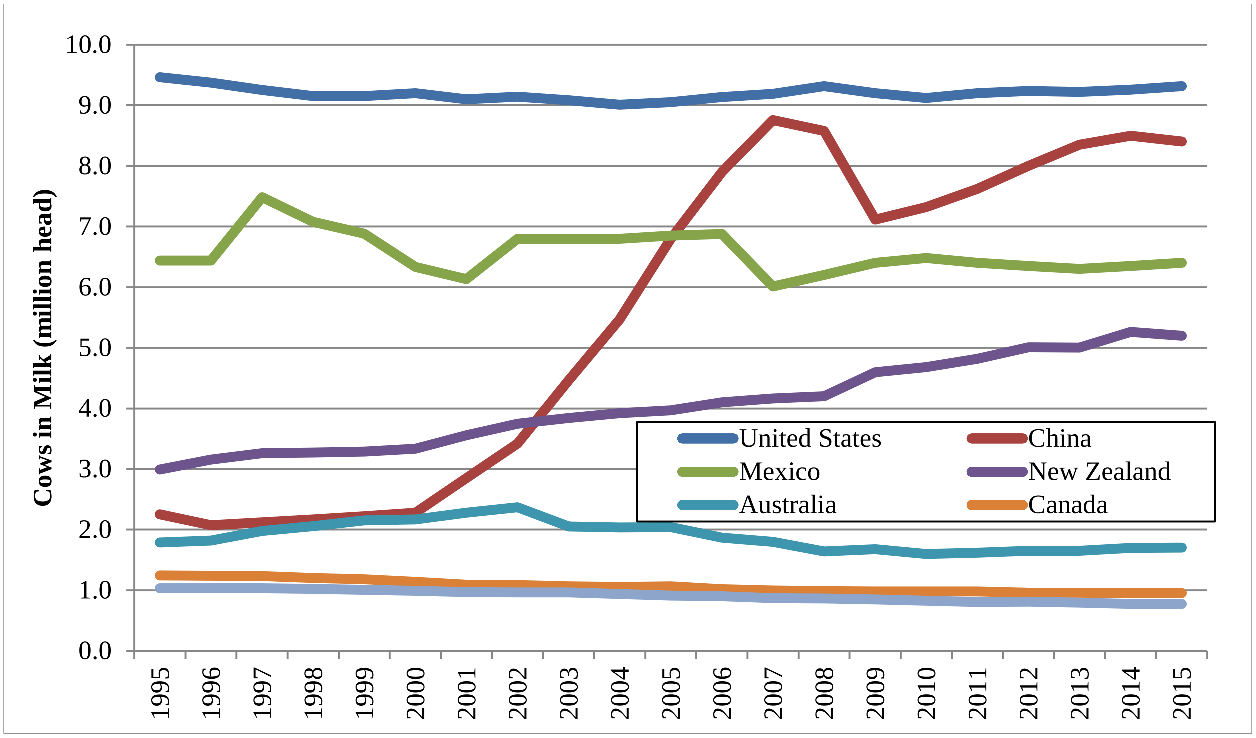

Figure 5. Size of dairy herd in leading dairy countries (1995–2015)
Source: USDA Foreign Agricultural Service's PSD Database

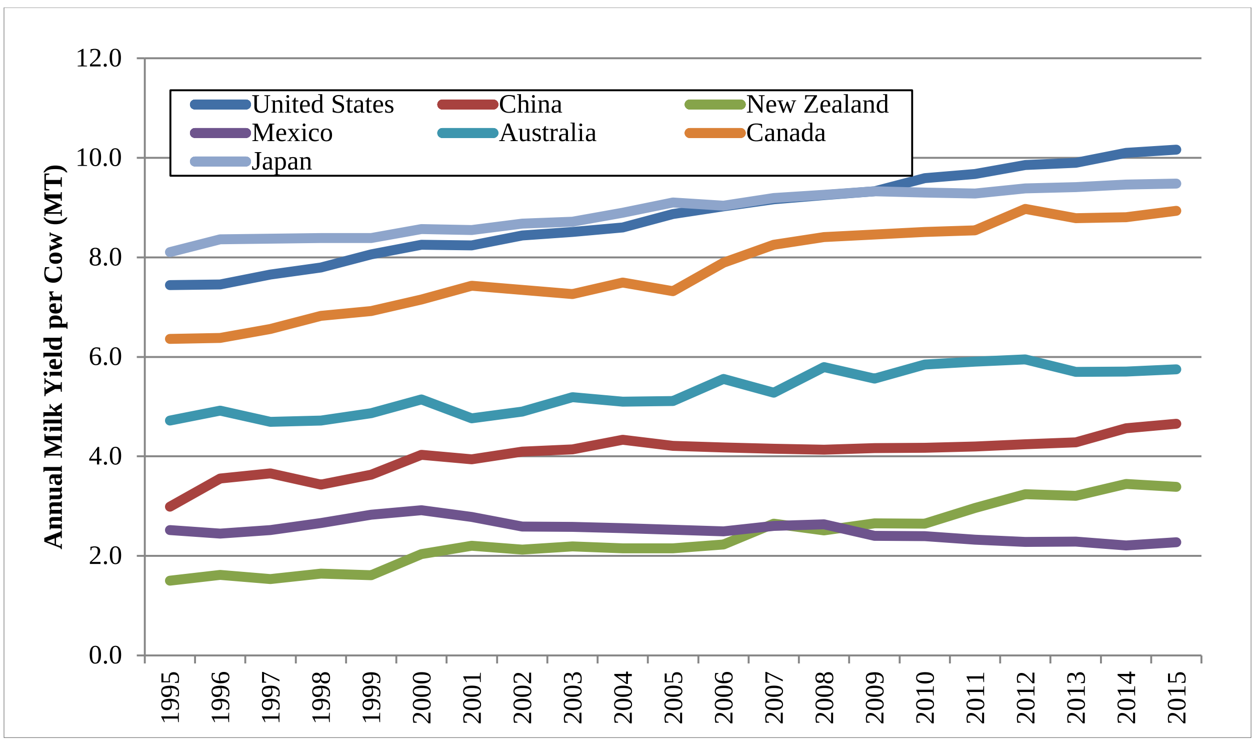

Figure 6. Annual milk yields per cow by country, 1995-2015. (USDA FAS 2015)
Source: USDA Foreign Agricultural Service's PSD Database

Increased Demand for Quality Forage Crops

A major challenge facing China, and other land-scarce Asian countries, is access to high-quality forage for dairy cattle (Zhu et. al. 2013; Wang, 2011). This is a necessary input to complement improved cow genetics and increase productivity while reducing costs (Li and Frederick 2015). Although dairy cows are fed many types of plant products, from a nutritional perspective, feeds provide a range of specific functional nutrients (Putnam 2008). Both grassy hays and alfalfa hays have been exported in large quantities, but alfalfa dominates the large emerging dairy markets in China and other Asian countries (Putnam et al. 2013, Putnam et al. 2016).

Forages deliver several important components in modern dairy cow rations:

- Energy—the ability to supply energy available per unit dry matter, released either directly (starches, sugars) or through ruminant fermentation.
- Intake—the ability of a forage to rapidly (but not too rapidly) degrade to yield energy and protein.
- Protein—the ability to supply both rumen available and rumen by-pass protein to be effectively absorbed by the animal.
- Fiber (NDF)—the functionality of fiber to enable proper rumen function, microbial health, pH stabilization, and salivation, and animal health.
- Minerals—provision of the proper mineral balance.

While many types of feeds supply several of these attributes of importance for dairy cow nutrition, not all feeds supply all nutrients, which is why mixtures of different feedstuffs are the norm to balance modern rations. The forage component of most modern dairy diets is dominated by a combination of corn or sorghum silage and alfalfa hay, with other forages (miscellaneous grasses) playing an important role in some cases. Forages are typically 45–60% of diets, with grains and protein supplements typically making up the remainder of the ration.

Dairy cows require NDF at a minimum level, and that NDF (fiber) must be digestible. Functional fiber is probably the unique quality provided by alfalfa and hay that cannot be provided by other feedstuffs such as grains or corn silage. However, high-quality forages such as dairy-quality alfalfa hay provide a combination of digestible energy, high intake, protein, and effective fiber, which results in high levels of milk production, and thus is highly prized by dairy nutritionists. Producers formulate feed rations for ruminant animals in general, and specifically for dairy cattle, to provide adequate quantities of crude protein, energy or net energy for lactation in dairy cattle and long fiber.

China and other Asian countries face several limits on their ability to domestically produce high quality forages such as alfalfa.

- **Access to Water Where Climate is Suitable.** Adequate rainfall or irrigation is likely the most important limiting factor for forage production worldwide. Forages require significant water resources for their maximum economic yield, although water-use efficiencies are generally high.

- **Environmental limitations.** Depending upon the species considered (alfalfa, grass), low ph., drainage, excessive or untimely rainfall during harvest, excessive cold (short growing season, lack of persistence) or heat, salinity, shallow infertile-soil, or excessive disease or other pests can impose severe limits on the production of alfalfa and other forages.
- **Competing Crops, including those Favored by Governments.** Many of the best agricultural ground has been (or will be) allocated to higher-revenue per hectare grain, oilseed, vegetable, and specialty crops which provide income opportunities and are often favored by government policy.
- **Infrastructure.** The development of domestically traded forages requires infrastructure for rapid baling, handling, and processing. Service industries such as seed, chemicals, and harvesting equipment are also needed and can be a limiting factor currently in many Asian regions.
- **Technology/Expertise/Support.** The production of high-quality alfalfa or grass hay requires expertise in production and marketing that is often lacking currently. Technology tends to be highly transferable but takes time and support.

The lack of quality forage crops grown domestically in Asian countries has created recent opportunities for forage producers in the Western US states, including California.

Exports of Forage Products from US West Ports

Prior to 2007, US exports of forage crops to the Asia-Pacific region were minimal. Since the middle of the past decade, hay and forage crop exports from the United States to Asian destinations have increased substantially. California forage producers have specifically benefited from this increase with California hay exports increasing in value from less than $95 million in 2006 to almost $290 million in 2014 (UC AIC). About 99% of US hay exports are shipped from West Coast ports of California, Oregon, and Washington. Average annual volume of forage crop exports in the 2013–2015 period was 24.5% higher compared to the 2007–2009 period despite the California drought discussed below (Table 2). The largest share of this increase comes from the export of alfalfa hay to Asia, which saw a 61% increase in volume during this time period (Table 3).

Table 2. Three-year average value of western states' alfalfa hay exports by destination region during periods 2007–2009, 2010–2012 and 2013–2015.

Global Region	2007–2009 ($Million)	Share	2010–2012 ($Million)	Share	2013–2015 ($Million)	Share
Asia	2,893	89%	3,308	81%	3,602	85%
Mid East/N Africa	284	9%	732	18%	575	14%
Mexico and Canada	41	1%	53	1%	31	1%
Rest of World	0	0%	1	0%	1	0%
Total	3,219	100%	4,095	100%	4,209	100%

Source: U.S. International Trade Commission, DATAWEB

Table 3. Three-year average volume of alfalfa hay exports from western ports by destination region during three-year periods 2007–2009, 2010–2012 and 2013–2015.

Global Region	2007-2009 (1,000 MT)	Share of Total	2010-2012 (1,000 MT)	Share of Total	2013-2015 (1,000 MT)	Share of Total
Asia	1,010	80%	1,236	67%	1,629	78%
Mid East/N Africa	205	16%	553	30%	435	21%
Mexico and Canada	36	3%	47	3%	26	1%
Rest of World	0	0%	0	0%	0	0%
Total	1,251	100%	1,837	100%	2,090	100%

Source: U.S. International Trade Commission, DATAWEB

California as Future Supplier of Asia's Forage Crop Needs

Under normal conditions, the Western United States, and California specifically, are well suited to continue supplying the forage crop needs for Asia's expansion of domestic dairy production. Historically, the California forage industry has not faced the same constraints as Asian forage producers. California's Mediterranean climate, fertile soils and abundant supply of water for irrigation have been ideal for the growth of the state's forage industry. In addition, the geographic proximity of California producers, and producers in western states to major West Coast ports, and the availability of advanced shipping technology, such as double compression of hay bales, further lowers the costs of Asia importing hay from California. A key factor in the increased hay exports has been very favorable export shipping rates to Asia due to a severe imbalance of trade and many empty containers available for western shipping routes.

However, changes in climate has affected western states' competitiveness in supplying forage products to Asia. For example, in recent years California forage growers have faced challenges related to water availability and competition for land from other crops. Since 2000, alfalfa acreage in California has gone from a high of 1.16 million acres in 2002 to 820,000 acres in 2015. For the first part of this period, alfalfa production declines were matched by expansion in corn silage production. But annual average acres of alfalfa in California over the past five seasons are just over 860,000 while silage acreage has also fallen during the recent drought. In 2015 approximately 542,000 irrigated acres of agriculturally productive land was idled, which is 114,000 more acres than 2014 (Howitt et. al. 2015). Farmland used to produce feed, grain and hay crops comprise the largest share of idled irrigated land in 2015. These crops have been cut back in favor of crops such as tree nuts and vegetables which have higher revenue per unit of water. If drought conditions are a result of climate change and continue indefinitely, acreage dedicated to alfalfa and hay production could diminish more, raising the cost of exports. Australia and parts of Europe offer limited competition in the Asian forage products market but this could change if production costs in California increase.

The main source of demand for alfalfa and other forages domestically and internationally is the dairy industry. As noted, California produces about 20% of US milk annually and accounted for about 40% of US exports of dairy products (Sumner 2014). About 80% of the milk produced in California is processed into tradeable manufactured products such as butter, cheese and dry milk powder. Less than 15% of California milk is consumed as beverage products (Sumner 2014).

California dairy products such as dry milk powder, cheese and whey are shipped to US, Mexico and Asian markets (UC AIC).

California Exports of Dairy Products to Asia

Increased demand for dairy in Asia has led to significant increases in value and volume of US exports of processed dairy products out of West Coast ports (Table 4). Comparing the ten-year average annual values of processed dairy product exports to Asia and the rest of the world for 1996–2005 and 2006–2015, exports to Asia increased by $1.2 billion per year or more than four times the value, while total exports increased more than five times in value. Asia accounts for over 70% of total California dairy product exports during both periods (UC AIC).

Table 4. Ten-year average annual value of all processed dairy product exports from west ports globally and to Asia during periods1996–2005 and 2006–2015.

Global Region	1996–2005 ($Million)	Share of Exports	2006-2015 ($Million)	Share of Exports
Asia	276	81%	1,503	72%
Rest of World	63	19%	597	28%
Total	339	100%	2,099	100%

Source: U.S. International Trade Commission, DATAWEB

Along with value, the average annual volume of dairy product exports from West Coast ports globally and to Asia also increased substantially. Exports globally tripled in average volume over the past decade compared to the previous period while export volumes to Asia doubled (Table 5). Nationally, dairy exports as a share of annual production grew also. Between 2006 and 2013 exports of dairy products accounted for 1.6% of total US milk production. This share increased to 4% of annual production between 2006–2013 (USDA–ERS 2016). Accounting for almost 40% of total US dairy product exports, California's dairy industry saw substantial increases in value of dairy exports from under $800 million in 2006 to over $2 billion in 2013 and 2014 (UC AIC).

Table 5. Ten-year average annual volume of all processed dairy product exports from west ports globally and to Asia during periods1996–2005 and 2006–2015.

Global Region	1996–2005 1,000 MT	Share of Exports	2006–2015 1,000 MT	Share of Exports
Asia	249	81%	688	76%
Rest of World	41	0%	213	24%
Total	290	100%	902	100%

Source: U.S. International Trade Commission, DATAWEB

The export of processed dairy products from West Coast ports increased throughout Asia with the majority of gains coming from increased purchases by China, which accounts for an average of 27% of annual volume of dairy product exports to Asia between 2006 and 2015 (Table 6). Average annual volume of dairy product exports from West Coast ports to China during the ten years 2006 to 2015 tripled compared to the previous decade from 44,000 metric tons to 184,000 metric tons (Table 6). In aggregate, annual volume of exports to Asian countries increased over four times to 688 thousand metric tons.

Table 6. Ten-year average annual volume of dairy product exports from west coast ports to major Asia destinations by country during 1996–2005 and 2006–2015.

Asian Country	1996–2005 1,000 MT	Share of Exports	2006–2015 1,000 MT	Share of Exports
China/Hong Kong	44	18%	184	27%
Philippines	26	11%	81	12%
Japan	80	32%	105	15%
Vietnam	12	5%	57	8%
Korea	25	10%	63	9%
Indonesia	14	6%	69	10%
Malaysia	8	3%	43	6%
Rest of Asia	40	16%	86	13%
Total	249	100%	688	100%

Source: U.S. International Trade Commission, DATAWEB

The gains witnessed in dairy product exports to Asia from West Coast ports are primarily led by increases in the volume of export of cheese, butter and dry milk products (Table 7). Dry milk powders, whey products and lactose are the top exported dairy products accounting an average of almost 87% of total annual dairy export volumes to Asia over the past decade. Each of these main exported products increased significantly in export volume from the previous decade to the most recent (Table 7).

Table 7. Ten-year average volume of processed dairy product exports to Asia from west coast ports by product during periods 1996–2005 and 2006–2015.

Dairy Product	1996–2005 1,000 MT	Share of Total	2006–2015 1,000 MT	Share of Total
Dry milk powder	46	19%	201	29%
Whey products	93	37%	230	33%
Hard cheese	14	6%	72	10%
Lactose and casein	81	33%	170	25%
Butter and fat	0	0%	6	1%
Other dairy products	14	6%	9	1%
Total	249	100%	688	100%

Source: U.S. International Trade Commission, DATAWEB

Summary of an Econometric Approach

To supplement the descriptive examination of trends discussed above, we next turn to a brief discussion of econometric estimates of western exports of two key dairy products to the six major Asian importers.

Our focus here has been on longer run Asian demand consideration so we examine twenty years (1996 –2015) of annual export quantities for non-fat dry milk and whey to China, Japan, Korea, the Philippines, Taiwan and Vietnam. As explanatory variables we include exchange rate indexes, population, per capita income, a variable reflecting the implementation of the Korean Free Trade agreement and a dummy reflecting a shock to exports in 2012. The model also includes a lagged dependent variable to account for gradual adjustment and a fixed effect for each country to reflect permanent differences in market size and other characteristics.

Perhaps not surprisingly, these econometric models did not produce results suitable for forecasting. The many fluctuations and ad hoc shifts, with only twenty years of data and focusing on only six Asian countries, did not allow estimation of statistically significant parameters. For several countries imports were almost zero for many years and fluctuated substantially from year to year more recently. Population was gradually expanding and could not account for variation in year to year imports. Gradual income growth too did not capture flux that was likely due to ad hoc shifts in policies as well as local supply conditions.

This more formal approach was informative in suggesting further work in which we estimate underlying parameters of income and population import elasticities from much larger data sets with more countries in which we also control for some local supply-side shifts and perhaps supply shift from export competitors. These estimated parameters could then be included in more formal forecast models.

Conclusions

Expanding populations and increased wealth in the developing countries of Asia are likely to increase demand for dairy products. To meet this demand Asia will likely increase dairy product supplies from three sources: (1) increased domestic milk production, (2) imports from Oceana and Europe and (3) imports of dairy products from the western United States.

Increasing domestic production of milk within Asia means expanding dairy herd size and improved productivity per cow. Both entail an increased demand for more high quality forages such as alfalfa hay. Asian countries are constrained by climate, land, infrastructure, government policy and technical expertise to produce enough domestic forage crops to support additional dairy production. The natural source for some of the needed forage is the western United States particularly the Pacific Northwestern states and California. Exports of western hay have expanded in recent years even as western milk production has grown and a drought has gripped California. However, drought, climate change and competition from other crops could reduce California's competitiveness in the Asian forage crops market.

Asian milk production alone will not meet the growing demand for dairy products in Asia. Exporting dairy products to Asia has expanded rapidly over the last decade and despite a decline in 2015 (driven by the collapse in dairy product prices) the average value of almost $1 billion per year for the past three years remains well above earlier periods. To remain competitive, however, Californian and other western US dairy and forage industries must improve productivity on farms and in processing at least to keep pace with productivity growth among competitors such as New Zealand and Australia, which face their own challenges.

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Diversification in Spanish Dairy Farms: Key Drivers of Performance

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Abstract

Recent downward trends in milk prices and the abolition of European Union (EU) milk production quotas have raised questions among Spanish farmers exploring whether diversification initiatives are profitable. The objective of this paper is to provide empirical evidence measuring the financial performance of value-added dairy farm ventures. The study analyzes forty-nine farms in Northern Spain that have diversified activities through milk commercialization and related niche products. Data collected through in-depth interviews with farmers shows that knowledge management, management control systems (MCS) and a differentiated value proposition for customers positively affect performance. Contrary to what is expected, networks and the technological level of the ventures (innovation of the production process and the use of IT systems) do not assure positive performance outcomes.

Keywords: farm diversification, resource-based view, balanced scorecard, Spain, dairy farms

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Introduction

The restructuring of the agricultural sector resulting from globalization and the Common Agricultural Policy (CAP) reforms in the European Union (EU) has driven numerous farms to defend their competitive position via diversification activities (Rønning and Kolvereid 2006; Grande 2011; Vik and McElwee 2011). One type of diversification promoted by the EU and supported by the new CAP 2014–2020, consists of incorporating value-added to agricultural products through food processing and direct marketing (Santini and Paloma 2013).

Specifically, in the EU since 2003, a series of reforms to CAP have led to market forces now being the main determinant of milk prices. Consequently, milk prices have fallen due to cuts in intervention prices, becoming more in line with world prices. After the latest CAP reforms and quota abolition in 2015, both farmers, as well as the processing industry will need to learn how to survive in a more market-oriented context. Most producers are characterized by low bargaining power in the food chain and are focused on milk production as a commodity—the price of which is highly volatile and dependent on global market conditions.

Although annual milk production in the EU exceeds consumption of dairy products, milk production in Spain does not cover the Spanish demand. Total milk consumption in Spain amounts to approximately 9.5 million tons of milk equivalent, and only 74% of which is covered by domestic production. The deficit between domestic consumption and production is supplemented with imports, almost all of which come from other European countries. Cheese accounts for more than half of these imports. The Spanish dairy industry is focused on liquid milk, and the store brands have 55% of the market share of drinking milk and fresh products. With the removal of quotas, there is an opportunity to improve the level of coverage of domestic demand, although there are new threats such as competition from other European countries that are expanding production and the risk of abandonment of production in less competitive regions (Sineiro and Vázquez 2014).

In this context, there are dairy farms that try to survive adopting a niche market strategy that is more attentive to local food demand, getting into the business of processing and adopting more sophisticated marketing schemes. The definition of the term ‘local food’ applied in this work is focused on the quality dimension as opposed to the geographical dimension of the concept. Under this approach the product is not necessarily consumed in the same region or locality of origin and ‘is identified and distinguished using product labels, certification systems and other production parameters such as artisanal, traditional, farm-based, organic or natural to define and differentiate the quality of the specific product coming from a geographic area’ (Abatekassa and Peterson 2011: 44). These initiatives allow farmers to reduce risks such as those related to over-dependence on a small number of clients and the downward pressure on agricultural and livestock raw material prices exerted by the agri-food industry and large-scale distribution companies. Nevertheless, direct marketing strategies generate new commercial risks, as well as increased costs due to, among others, additional labor force requirements (Santini and Paloma 2013).

Value-added ventures may provide a way of supporting milk production in less favored areas after quota abolition (Committee of the Regions 2014). Moreover, local products can be a source of a differentiated supply with future export potential, as in the case of Italy— a country with milk production below consumption and at the same time with significant exports of traditional cheeses (Jongeneel 2011: 250). Different agents with interests in the dairy sector, such as entrepreneurial farmers, their advisers, and public administrations, are interested in understanding the critical factors that explain the success of these value-added ventures.

This study explores the effect of intangible resources and capabilities on the performance of rural enterprises that diversify their activity via new value-added business. For this purpose, we have studied the case of Spanish dairy farmers that have undertaken this type of entrepreneurial initiative through the elaboration and commercialization of different dairy products such as, among others, liquid milk, cheese and yogurt.

A growing amount of literature exists in relation to the diversification of agricultural holdings and the potential advantages that this type of business strategy offers: increased profits, positive effects on employment, introduction of business dynamics, the stabilization of rural populations (e.g. Carter 1998, 2001; Barbieri and Mahoney 2009; Grande 2011; Vik and McElwee 2011). Thus, previous studies have explored the different types of diversification in the agricultural sector (McNally 2001; McElwee and Bosworth 2010) and the motives underpinning these initiatives (Barbieri and Mahoney 2009; Vik and McElwee 2011; Amanor-Boadu 2013). However, few empirical studies have uncovered evidence on the effect of diversification on financial performance. In fact, the evidence available suggests that the expected profits are not always achieved, further highlighting the need for more research on the factors influencing the economic success of these types of strategies.

A review of the research suggests that there is not a consensus about the main explanatory factors of performance, perhaps because the theoretical literature on rural entrepreneurship is still incipient (Pato and Teixeira 2013). This also explains in part the predominance of qualitative research, which has resulted in different authors demanding statistical studies in order to improve the validity of results (Haugen and Vik 2008; Grande 2011; Walley et al. 2011).

The objective of this paper is to help fill the research gaps described above and provide empirical evidence regarding the performance drivers and diversification strategies of milk processing and the sale of dairy products. For this purpose, we use a conceptual model based on the Balanced Scorecard framework (henceforth, BSC) (Kaplan and Norton 1992) that reflects how value is created in firms.

The BSC is the performance measurement model receiving the greatest attention from companies and researchers in management in recent years. The principal advantage of BSC is that it offers a template in which financial-related measures complement other operational, non-financial measures of customer satisfaction, internal processes, learning, and growth. The non-financial measures grant some insight into those intangible resources (such as human capital) and capabilities which, according to the resource-based view (RBV), play a decisive role in the performance of new farm-based ventures (Grande 2011; Grande et al. 2011; Walley et al. 2011). The financial and non-financial measures are linked by causal relationships which reflect the value-creation process in companies (Bryant et al. 2004).

The empirical analysis has used data provided by a sample of forty-nine dairy farms located in Northern Spain to study whether knowledge management, networks, internal processes (application of management control systems or MCS and technological level) and customer value proposition have an influence on financial performance. In order to test the established hypotheses between drivers and performance, a model of structural equations is employed applying the technique of Partial Least Squares (PLS).

Subsequent sections of this paper are organized as follows: a literature review and development of the research hypotheses and methodology employed in the study; a presentation of results and discussion of contributions; followed by a section presenting the conclusions and limitations of the study.

Theoretical Framework and Hypotheses

Resource-Based View

The resource-based view (RBV) supports the idea that in order to create and maintain a sustainable competitive advantage, organizations should develop internal capabilities which allow them to optimize resources and achieve greater returns (Teece et al. 1997). Resources include diverse elements which can be used to implement strategies for the creation of value for a firm and can be classified as physical, human and organizational. Those resources considered valuable, rare, inimitable and non-substitutable, can lead to the achievement of a sustainable competitive advantage which cannot be easily replicated by competitors (Eisenhardt and Martin 2000).

Although possessing resources that are difficult to imitate assures that an organization has the potential to improve its performance in the long-run, it's the firm's ability to exploit them that permits a sustainable competitive advantage over time (Eisenhardt and Martin 2000). Organizational capability can be defined as the firm's ability to use resources: integrate, reconfigure, gain and release resources—to match and even create market change (Teece et al. 1997). Among those capabilities necessary for achieving competitive advantages are organizational learning, networking capability, innovation, market orientation and entrepreneurial spirit (Henri 2006; Chen et al. 2009).

The RBV has been used in previous studies of farms which have followed initiatives for diversification (Alsos and Carter 2006; Grande 2011; Grande et al. 2011; Walley et al. 2011). A review of this research suggests that intangible assets, such as human capital, or determined business capabilities, such as organizational learning, networking or entrepreneurial spirit play an important role in the economic success of agricultural diversification.

The Balanced Scorecard (BSC)

The Balanced Scorecard (BSC) is, probably, the most popular and widely known among causal performance measurement approaches. The BSC was developed to overcome the tendency of managers to focus almost exclusively on short-term financial performance measures while disregarding non-financial performance measures (Kaplan and Norton 1992). The BSC framework measures the performance of an organization from four perspectives, one financial and three non-financial: learning and growth, internal processes and customers.

The model includes lag measures (measures of results such as financial) with lead measures (performance drivers, such as the skills of human resources, new products introduction or customer satisfaction) for the four perspectives already mentioned and linked via causal relationships. This can be described as a relatively simple value-creation process where each perspective incorporate outcome measures that are drivers of only the next perspective in the hierarchy (Bryant et al. 2004): learning and growth → internal processes → customers → performance. However, previous empirical work has shown that the causal relationships between perspectives can be seen more as a 'complex' value-creation process, in which the improvement of each perspective not only affects the next one in the hierarchy ('simple' value-creation process) but also the rest of the higher level perspectives (Bryant et al. 2004; Cohen et al. 2008; Bento et al. 2013).

Although the BSC is used mainly as a management tool, in this study we use it as a conceptual framework in order to articulate the links between leading inputs, processes, and lagging outcomes (Abernethy et al. 2005). On the other hand, the inclusion of non-financial measures proposed by BSC allows us to reflect those intangible resources and capabilities that, as mentioned above, could explain the economic success of agricultural diversification. Furthermore, BSC is sufficiently flexible to allow the incorporation of variations to suit each organization.

Using the BSC framework, Figure 1 displays our research model, where H_i are the hypotheses. The model shows that the learning and growth perspective (human capital and networks) influences the internal processes (application of management control systems or MCS and the level of technology), which in turn affects the customer value proposition (offer of a traditional product with high standards of welfare, environmental or of another type), which impacts performance. Additionally, in line with the 'complex' value-creation process, each perspective influences all the higher-level perspectives. The discussion of the variables used and the causal relationships proposed are summarized below.

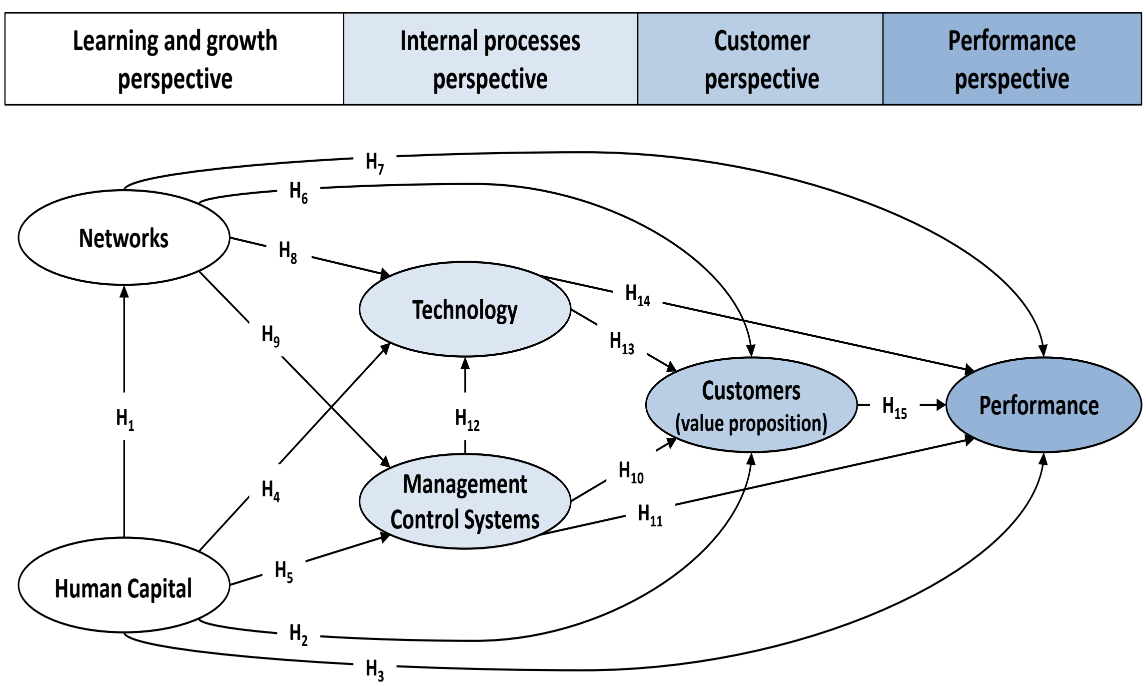

Figure 1. Research Model

Financial Perspective: Performance

The financial perspective describes the results of the strategy in traditional financial terms. The metrics included in this area are considered lagging measures since they are the result of previous actions, mainly of a qualitative nature.

The goals that drive the decision to undertake diversification initiatives are both financial and non-financial, such as the continuance of farming, or the enhancement of family's quality of life (Barbieri and Mahoney 2009), so an appropriate measurement of performance should include financial and non-financial indicators. Nevertheless, previous studies of the sector have only used financial indicators to reflect performance (Skuras et al. 2005; Alsos and Carter 2006; Grande et al. 2011), in part, because the generation of additional income continues to be the predominant objective, given the economic nature of any business venture.

Furthermore, various studies use qualitative metrics (based on the perceptions of the businessmen interviewed) of financial performance, where the firm compares itself to competing firms within the same industry (Alsos and Carter 2006; Grande et al. 2011). The use of qualitative indicators tries to overcome some of the limitations found in quantitative indicators based on accounting data. Hence, accounting profit can experience an alteration due to the way the accounting criteria is applied and can be understood more as a measure of past rather than present or future success. Moreover, accounting data for farms is not always readily accessible.

Learning and Growth Perspective: Human Capital and Networks

The learning and growth perspective reflects the intangible assets necessary for achieving the other three perspectives (Kaplan and Norton 2000). A review of the literature reveals two critical assets in agricultural enterprises: human capital and networks.

Human capital management. Human capital comprises a combination of skills, aptitudes, and attitudes of the employees. Previous studies have found a positive effect of human capital in the returns from agricultural holdings (Skuras et al. 2005; El-Osta 2011) and underlined its importance for diversification (Haugen and Vik 2008). These papers use proxy measures such as age and/or the education of the entrepreneur in order to reflect the human capital employed. However, human capital management goes far beyond the level of human capital possessed by the manager of the farm.

Farms which embark upon diversification initiatives tend to be characterized as being micro-enterprises containing a significant family labor component, closely related to the entrepreneurs and the persons responsible for decision-making. The success of these initiatives is determined to a great extent by the capacity of persons to work as a team and to establish agreements with other entities. In order to achieve competitive improvements in production and commercialization, workers must display a proactive attitude towards building new knowledge which can be shared and applied.

Thus, appropriate knowledge management is required, and the following hypotheses are proposed:

H1: Knowledge management is positively related to the creation of appropriate networks.

H2: Knowledge management is positively related to the customer value proposition.

H3: Knowledge management is positively related to performance.

H4: Knowledge management is positively related to the level of technology.

H5: Knowledge management is positively related to the use of MCS.

Networks. The capacity for networking (also known as social capital, external links or personal networks*)* refers to the ability to identify, establish, coordinate and develop relationships with different market 'players' (Chen et al. 2009). The use of networks facilitates access to information, resources, and markets. Its importance will be greater for small and rural enterprises facing less favorable conditions in terms of location, information sources, market proximity, and the possibility to develop their own R&D (Grande et al. 2011). The appropriate networks can help them to maintain themselves updated with respect to new technologies and market changes, contributing towards offering adequate responses to opportunities or emerging threats (Chen et al. 2009).

In the literature on agricultural diversification, various studies have highlighted the important role played by the construction of formal (professional) and informal networks (social) in the success of new initiatives (Clark 2009; Grande 2011). Other work reveals that networks can also be prejudicial if relationships are unbalanced, in particular—those formed with large distribution companies, or excessively traditionalist—those preoccupied with preserving craft knowledge (Alsos and Carter 2006; Blundel 2002).

Based on the above and given the possible importance attributable to the construction of appropriate networks for obtaining information, resources and knowledge in the farms developing new projects, we pose the following hypotheses:

H6: The ability to construct networks is positively related to the customer value proposition.

H7: The ability to construct networks is positively related to performance.

H8: The ability to construct networks is positively related to the level of technology.

H9: The ability to construct networks is positively related to the use of MCS.

Internal Business Processes Perspective: Management Control Systems and Technology

This perspective identifies the key processes necessary to provide a customer value proposition (Kaplan and Norton 1992). Two internal processes can be considered relevant for accomplishing the value proposition: the use of MCS and the technological level of the farm (innovation and quality in the production process and use of IT systems).

Management control systems (MCS). Although the management capacity of dairy farms has normally been treated in the literature as a 'black box' due to the complexity of its measurement, some papers have considered this key factor as a way of improving farm efficiency (Hansson

2008). Previous studies in other sectors acknowledge the effect of the use of MCS on economic results (performance) and its importance in the innovation process (Chapman 1997).

Furthermore, for the value proposition to be sustainable, customers should be prepared to pay a premium price for the attributes which they perceive in the product. Achieving prices which are not too high in relation to conventional products demands cost control from those holdings focused on local farming.

Consequently, it can be hypothesized that the use of MCS allows appropriate decision-making which contributes to an improvement in the value proposition to customers, internal processes and, ultimately, will positively affect the economic results of the company:

H10: The use of MCS is positively related to the customer value proposition.

H11: The use of MCS is positively related to performance.

H12: The use of MCS is positively related to the technological level.

Technology. The level of technology refers to the processes which contribute towards fulfilling customer expectations: innovation and quality of the production process and the use of IT systems. In the food sector, innovation includes the adoption of new technologies which allow companies to achieve higher quality standards, new ways of presenting traditional products, diversification of the products offered or new functions incorporated into products (Capitanio et al. 2010). In fact, for the farms focused on value-added processing, innovation does not imply outlays of R & D, but instead is implemented, for example, by increasing their portfolio with higher value-added products or by differentiated packaging; likewise, holdings seeking a certificate of protected designation of origin (PDO), or an organic label require investment in the technology of the production process which will permit them to maintain constant quality standards adapted to the conditions required by the appropriate regulatory board.

Furthermore, the capacity for market orientation can be defined as the generation by the organization of market information on present and future consumer needs, dissemination of this information among personnel and the response by the whole organization to it, in a search for increased returns (Kohli and Jaworski 1990). The use of IT systems facilitates information flows and permits a substantial improvement in all administrative activities within the companies.

In light of the above, it is suggested that the technological level has a positive effect on the customer value proposition (providing attributes valuable to the latter such as traceability, the PDO label, etc.) and on performance (more modern and efficient technology and the use of IT systems that can contribute towards cost control):

H13: The technological level is positively related to the customer value proposition.

H14: The technological level is positively related to performance.

Customer Perspective

This perspective defines the value proposition used by the company to secure sales from target customers. A generic measure of this appearing in the BSC found in the majority of organizations is client satisfaction, although other attributes should be considered in accordance with the value proposition which, if satisfied, allows the company to retain and expand its client database (Kaplan and Norton 2000).

Farms which undertake initiatives of processing and commercialization of traditional products have little margin to compete price wise in terms of economies of scale. Their strategy is based on industry differentiation, and they seek to achieve a market niche populated by consumers who demand traditional products requiring high *welfare* standards, environmental or otherwise (Gilg and Battershill 1998). Different studies show that consumers like purchasing local agri-food from products for varying reasons, such as environmental, a quality perception of these products, contribution to the maintenance of rural economies and communities, etc. (Santini and Paloma 2013). Based on this the following hypothesis is posed:

H15: The ability to fulfil the customer value proposition is positively related to performance.

Methodology

Sample Selection and Description

Although most of the milk produced by Spanish dairy farms is sold directly to the processing industry, a certain number of entrepreneurial farmers have embarked on the implementation of diversification strategies. No specific register exists for dairy farms that perform activities of production and commercialization of dairy products and for this reason we resorted to identifying them through searches on the Internet and enquiries to agents from the dairy sector (cooperatives, advisors, producer organizations, regulatory organisms of the different PDO and organic agriculture, etc.). This study centred on four regions of Northern Spain (Asturias, Cantabria, Galicia and the Basque Country), where according to 2013–2014 data supplied by the Ministry of Agriculture, Food and Environment, 79% of the farmers and 59% of Spanish dairy production is located (Ministerio de Agricultura 2015). Collaboration was requested from the eighty cases identified, resulting in the participation of forty-nine farms—fourteen of which are certified organic and of the product references sold, 16% possessed a PDO label.

In the early months of 2011, an initial draft of the questionnaire was prepared. During the last months of 2011 more than twenty interviews were held with farms owners in order to achieve the best possible knowledge concerning the activity being undertaken. The study also benefited from a collaborative group of twenty-five Spanish experts possessing in-depth knowledge of the dairy activity and the rural sector (farm advisers, scientists, farm union staff, government representatives, industry managers, etc.), who provided opinions regarding successful farming diversification initiatives. For these experts, the most important factors were the management ability of farmers and the differentiation of their production within the market via various channels such as packaging, direct contact with consumers, sales in specialized shops, PDO, an organic label, and the attributes of the local and traditional product.

The results from this process were used to elaborate the definitive questionnaire used during 2012 in order to collect information for use in this study via on-farm interviews.

The sample answers revealed the following characteristics of interest corresponding to the data for the year 2011:

- The median quantity of processed milk per farm amounted to 280,000 liters, with percentiles of twenty-five and seventy-five, equal to 146,000 and 450,000 respectively. Approximately 50% of the sample farms transforms more than 40% of the milk produced on the farm, with 24% of the sample farms processing a volume of milk surpassing that produced by their herd, subsequently requiring external procurement of the milk. Cheese represents 54% of total sales, liquid milk 23%, yogurt 11% and other products 12%.
- In terms of marketing channels, sales to end consumers represents 35%, hospitality 21%, shops 30%, and large-scale distribution 14%.
- The average amount of investment dedicated to processing and marketing of dairy products amounted to Euros 258,500 per farm, 76% allocated to assets related to milk processing and the rest of product marketing and distribution.
- The average number of workers per farm was 4.8: approximately two-thirds of these were engaged in activities related to the processing and marketing of products, with the remaining third being assigned to the livestock activity.

Variables

Each variable was constructed through various items, using as previous reference papers and, in some cases, adapting them to the characteristics of the dairy farms. The constructs used in the analysis are presented in Table 1.

The dependent variable, performance, was constructed using three items. The interviewees were asked what they considered the situation of their company to be compared with competitors in terms of (a) optimization of the investment in assets, (b) competition from the company and (c) profitability of the company. A 5-point Likert scale was used to quantify the answers in each case, ranging from 1, ‘very inferior to competitors’ to 5, ‘very superior to competitors’.

The independent variables were constructed using the items shown in Table 1. For the purpose of measuring the perspectives for learning and growth and for internal processes the interviewees were asked to value the degree of implementation of the different practices over the past three years on a scale ranging from 1, ‘very little implementation,' until 5, ‘a lot of implementation.' In order to measure the customer perspective, interviewees were asked to value three aspects of their company as compared with the competition: (a) ability to make quality products, (b) the responsibility of the company with respect to the environment, (c) customer satisfaction. The measurement of each item was conducted with a scale ranging from 1, ‘very inferior to competitors’, until 5, ‘very superior to competitors’.

Table 1. Constructs used in the analysis

Items	Previous Studies
Financial Perspective: Performance (From 1, 'very inferior to competitors', until 5, 'very superior to competitors')	Alsos and Carter (2006); Grande et al. (2011)
P1. Optimization of the investment in assets	
P2. Competitiveness of the company	
P3. Profitability of the company	
Learning and Growth Perspective (From 1, 'very little implementation', until 5, 'a lot of implementation')	
Human Capital	Bontis et al. (2000); Massa and Testa (2009)
HC1. Workers propose innovations in the tasks related to production & processing	
HC2. Workers benefit from continuous learning dynamics	
HC3. Workers share new knowledge with colleagues	
Networks	Clark (2009)
N1. A working relationship is established with customers	
N2. A working relationship is established with competitors	
N3. A working relationship is established with other agri-food companies	
Internal Business Processes Perspective (From 1, 'very little implementation', until 5, 'a lot of implementation')	
Management Control Systems (MCS)	Chenhall and Langfield-Smith (1998); Henri (2006); Hansson (2008)
MCS1. Calculation and analysis of product costs and/or services for decision-making	
MCS2. Feasibility studies for investments	
MCS3. Economic and financial analysis of the company´s situation	
MCS4. Profitability analysis of products and services	
Technology	Maranto-Vargas and Gómez-Tagle (2007); Van Hemert et al. (2013)
T1. Mechanisms exist for obtaining, transmitting and sharing information of interest to the company	
T2. Information technologies are usually employed	
T3. The company usually proposes innovation with respect to the production process	
T4. It procures to avail itself of the necessary means in order to perform the major part of the company´s production process	
Customer Perspective (From 1, 'very inferior to competitors', until 5, 'very superior to competitors')	Gilg and Battershill (1998); Santini and Paloma (2013)
C1. Ability to make quality products	
C2. Responsibility of the company with the environment	
C3. Customer satisfaction	

Partial Least Squares (PLS)

We use PLS to analyse the hypotheses proposed. PLS is a technique based on structural equations that allows specification of models with complex relationships between observable and latent variables. A latent variable is not directly observable, being instead a construct made from other variables that theoretically form (formative indicators) or reflect (reflective indicators) a factor of interest for the study (represented by the latent variable). This technique has been widely used to analyse relationships between variables obtained from survey responses.

PLS path modelling is recommended in the early stage of theoretical development in order to test and validate exploratory models, being particularly suitable for prediction-oriented research (Henseler et al. 2009).

A PLS path analysis is based on two models, one of which is a measurement model, also called the outer model, relating the indicators to their own latent variable, and a structural model or inner model, relating some endogenous constructs to others. In our measurement model we use reflective indicators, which implies that the non-observed construct gives rise to observed indicators. PLS works well with small samples and complex models. The size of our sample, forty-nine cases, complies with the recommendations on the minimum sample size set by Hair et al. (2014: 20-22).

Estimation and Results

Measurement Model: Internal Consistency

The measurement model addresses relationships between each construct and its indicators and is based on the calculation of the principal components. The constructs must fulfil certain internal consistency properties: unidimensionality, reliability, convergent validity and discriminant validity.

Unidimensionality. A principal component analysis is carried out for each construct. A construct may be considered unidimensional if the eigenvalue of the first principal component is greater than 1 and smaller than 1 for the others. Another important factor is the percentage of variance explained: the first component being required to explain most of the variance. Table 2 shows that the requirement of unidimensionality is met for all the constructs analyzed.

Reliability. This measures the consistency of the indicators that make up the construct. All of the indicators should be measuring the same concept. Cronbach’s alpha (Cronbach 1970) and the composite reliability (Werts et al. 1974) are calculated, ranging from 0 (absence of homogeneity) to 1 (maximum homogeneity). Cronbach’s alpha assumes a priori that each indicator of a construct contributes in the same way, while the composite reliability uses the loadings of items as they exist in the causal model. When speaking of reliability, the usual requirement is that the values of both indices should be above 0.7. It can be seen in Table 2 that these indices exceed this minimum threshold in all cases.

Table 2. Unidimensionality, reliability and convergent validity of constructs.

Constructs and indicators	Unidimensionality				Reliability		Convergent Validity	
	Eigenvalue 1st P.C.	2nd P.C.	(%) Variance explained by 1st P.C.	2nd P.C.	Cronbach's α	Composite Reliability	AVE	Loadings
Networks	3.44	.84	68.76	16.91	.767	.858	.671	
N1. Customers								.903
N2. Competitors								.746
N3. Other agri-food companies								.800
Human Capital	2.61	.44	80.17	13.64	.876	.921	.797	
HC1. Workers propose innovations								.828
HC2. Workers in learning dynamics								.923
HC3 Workers share knowledge								.924
Performance	1.92	.56	68.24	19.98	.767	.865	.683	
P1. Investment optimization								.774
P2. Profitability								.895
P3. Competitiveness								.807
Customers	1.29	.37	71.07	20.70	.748	.856	.667	
C1. Quality								.908
C2. Environmental Responsibility								.780
C3. Customer satisfaction								.755
MCS	3.67	.57	71.68	11.18	.865	.904	.705	
MCS1. Cost calculations								.765
MCS2. Feasibility studies for investments								.823
MCS3 Financial analysis of the company								.881
MCS4. Profitability analysis of products and services								.884
Technology	2.63	.67	62.02	25.75	.776	.855	.599	
T1. Information systems								.825
T2. Use of IT								.829
T3. Innovation in the production process								.634
T4. Production process performed entirely by the company								.792

Convergent validity. This is the degree to which the indicators reflect the construct. The Average Variance Extracted (AVE) indicates the extent to which the construct variance can be explained by the chosen indicators (Fornell and Larcker 1981). The minimum recommended value is 0.5 (Baggozi and Yi 1988), which means that over 50% of the variance of the construct is due to its indicators. Table 2 shows that the AVE of all the latent variables exceeds the value of 0.5. A second approach to analysing the fulfilment of convergent validity is to check whether the factor loadings of the principal component matrix are greater than a given value for each of the indicators. Jöreskog and Sörbom (1993) recommend a value greater than 0.5, while Chin (1998) recommends a value greater than 0.7. The last column of Table 2 shows that the more stringent criterion (i.e., value greater than 0.7) is met in all cases except in one (T3).

Discriminant validity. This means that each construct should be significantly different from the other constructs. A factor loadings matrix was obtained to analyse the discriminant validity, as well as the cross-factor loadings. The factor loadings are Pearson correlation coefficients between the indicators and their own construct. The cross-factor loadings are Pearson correlation coefficients between the indicators and the other constructs. The factor loadings should be greater than the cross-factor loadings. Therefore, the indicators should be more closely correlated with their own construct than with the other constructs. This criterion is met in the proposed model, as shown in Table 3.

Table 3. Factor loadings matrix.

	Networks	Human Capital	Performance	Customers	MCS	Technology
N1	**.903**	.356	.179	.292	.465	.533
N2	**.746**	.218	–.210	.047	.199	.343
N3	**.800**	.314	–.045	.035	.186	.310
HC1	.230	**.828**	.346	.316	.087	.301
HC2	.235	**.923**	.393	.445	.179	.298
HC3	.462	**.924**	.395	.506	.395	.535
P1	.125	.331	**.774**	.360	.292	.030
P2	–.013	.391	**.895**	.50	.388	.073
P3	–.031	.325	**.807**	.445	.275	.093
C1	.190	.444	.536	**.908**	.338	.474
C2	.383	.451	.364	**.780**	.448	.463
C3	–.140	.284	.426	**.755**	.063	.251
MCS1	.181	.037	.182	.247	**.765**	.244
MCS2	.197	.195	.271	.173	**.823**	.230
MCS3	.405	.255	.397	.266	**.881**	.433
MCS4	.405	.338	.380	.441	**.884**	.472
T1	.433	.365	.103	.362	.385	**.825**
T2	.507	.231	.028	.290	.435	**.829**
T3	.306	.342	–.179	.278	.166	**.634**
T4	.335	.435	.198	.550	.350	**.792**

A second criterion for verifying the discriminant validity is to check that the square root of the AVE of the construct is greater than the correlation between that construct and all the others (Chin 1998). Table 4 shows the correlation coefficients between the constructs. The square root of the AVE is shown on the diagonal. The condition of discriminant validity is also met following this criterion. Furthermore, for Bagozzi (1994) the correlations between the different factors that make up the model should not be higher than 0.8—as occurs in this case.

Table 4. Latent variable correlations.*

	Networks	Human Capital	Performance	Customers	MCS	Technology
Networks	**.821**					
Human Capital	.370	**.893**				
Performance	.025	.424	**.827**			
Customers	.194	.488	.545	**.817**		
MCS	.387	.278	.390	.360	**.840**	
Technology	.509	.448	.080	.495	.444	**.774**

Note. *The square root of the AVE is on the diagonal

We have seen that the requirements ensuring internal consistency (unidimensionality, reliability, convergent validity and discriminant validity) are met. Latent variables can then be used to test the relationships in the model.

The Structural Model

PLS is used to estimate the structural equations with the aid of the SmartPLS software (Ringle et al. 2005), which allows standardized Beta regression coefficients called 'path coefficients' to be obtained. These coefficients are the basis for testing whether the proposed hypotheses are supported or not. Table 5 shows the standardized path coefficients and the *t* statistics. Because PLS makes no distributional assumption, traditional parametric techniques prove inadequate for analyzing the significance of the estimated parameters, and therefore resampling procedures such as bootstrapping are used. We applied a bootstrapping procedure with 5,000 samples that provides the standard error for each path coefficient. This information permits a Student's t-test to be performed for evaluating the significance of path model relationships.

The results shown in Table 5 reveal eleven significant path coefficients, allowing us the following observations:

- Knowledge management is associated positively with networks, customers, technology and performance, with no significant effect attributable to the use of MCS.
- The creation and development of networks affects the use of MCS and the technological level of these initiatives in a positive way. However it does not affect customers and performance significantly. These results would seem to indicate that networks have an effect on the internal processes of these farms, while not affecting in any direct manner the customer value proposition or performance.
- The use of MCS is associated in a direct way with the technological level and with performance, while it is not significant in relation to customers.
- The technological level displays two significant effects but with differing signs: a positive effect is associated with customers but a negative effect exists with respect to performance.

Table 5. Relationships between constructs.

	Beta	t-statistic
H1: Human Capital → Networks	.371***	2.67
H2: Human Capital → Customers	.348**	2.26
H3: Human Capital → Performance	.311*	1.93
H4: Human Capital → Technology	.261*	1.74
H5: Human Capital → MCS	.115	.96
H6: Networks → Customers	–.184	1.27
H7: Networks → Performance	–.119	.89
H8: Networks → Technology	.316***	2.59
H9: Networks → MCS	.330**	2.14
H10: MCS → Customers	.178	1.26
H11: MCS → Performance	.350***	2.58
H12: MCS → Technology	.249**	2.10
H13: Technology → Customers	.355**	2.25
H14: Technology → Performance	–.395***	2.70
H15: Customers → Performance	.487***	3.06

Note. *** 1% level of significance, ** 5% level of significance, * 10% level of significance

With a view to analysing the effect of control variables such as the age of the value-added venture and its size, estimations were performed with these variables but their effect on performance proved insignificant.

Table 6 shows the R^2, whose values measure the amount of variance of the constructs that are explained by the model. The R^2 of performance is 0.499. In order to evaluate the contribution of the remaining constructs to the R^2 for performance, the indicator f^2 effect size was determined to quantify the effect of the omission of each explanatory construct on the R^2 for performance. The interpretation of f^2 adopts the following threshold values: 0.02 for the small effect of the exogenous latent variable, 0.15 for the medium effect and 0.35 for the large effect (Cohen 1988). According to the values presented in Table 6 customers is the variable which exerts the greatest influence on the R^2 for performance.

The Q^2 test is used to assess the predictive relevance of the endogenous constructs. In line with our model, Q^2 values larger than zero imply that the model has predictive relevance. Similarly to f^2, the q^2 effect size is used to evaluate the relative effect of the remaining constructs on the predictive relevance of performance, showing that customers represents the construct with the largest impact.

Table 6. Evaluation of the structural model.

Constructs	R^2	f^2	Q^2	q^2
Networks	.137	.030	.086	.016
Human Capital	–	.136	–	.060
Performance	.499	-	.317	–
Customers	.373	.287	.237	.163
MCS	.171	.172	.110	.090
Technology	.389	.176	.229	.086

An analysis was performed of the total effects of each explanatory construct on performance. Using a bootstrapping procedure with 5,000 samples, t-statistics were calculated for each total effect, with those relating to customers, human capital and MCS being statistically different from zero, but not significant in the case of networks and technology (Table 7).

It is worth highlighting that these results are consistent with the valuation made by the panel of experts consulted, who indicated that the management ability of farmers and differentiation vis-à-vis the industry are the most relevant factors in the success of these new initiatives.

Table 7. Total effects on performance.

Constructs	Total Effects (Direct + Indirect)	t-statistic
Networks	–.153	.95
Human Capital	.425***	3.41
Customers	.487***	3.06
MCS	.381***	2.67
Technology	–.222	1.39

Note. *** 1% level of significance

Characteristics according to performance groups

With a view to describing the value-added ventures according to their level of performance, and thereby complement the results of the model described, the sample was ordered as per the estimated value of the variable performance to establish two groups, one with low profitability comprising twenty-five units with the lowest values and the other—high profitability, featuring twenty-four units with the highest values. Table 8 presents the average data for several of the variables which characterise the ventures as low or high, according to their level of performance.

Products are classified in four broad categories: liquid milk, yogurt, cheese and others. Four sales channels are considered: direct to final consumers, hospitality, shops and large-scale distribution.

The Mann-Whitney U test was used to investigate the existence of significant differences between the two groups. It is worth noting that the group with the high level of performance tries to adapt to a large extent its supply to different consumer segments and as such markets more product references, which correspond to different products and display formats. Likewise, the 'high' group centres its supply more on those products with more added-value than liquid milk, such as yogurt and cheese, just as the sales of organic products carry more weight in said group. These results are consistent with the importance of the customer value proposition as a variable which explains to a large extent the success of these initiatives of farming diversification.

We calculated the ratio for sales of dairy products to the investment undertaken for the processing and marketing of the former products, observing that the high performance group has the greater value, which supposes a higher level of asset turnover ratio in keeping with the behaviour of the construct performance. The return on investment in technical resources such as production installations, refrigeration and transport demands obtaining a specific total contribution margin to be reached with an adequate combination of sales volume and the per-unit contribution margin of the products.

Table 8. Characteristics according to performance groups.

	Low (25)	**High (24)**	**Significance**
Age of the venture (years)	13	10.2	
Sales of dairy products ('000s of €)	235.198	279.318	
Sales of liquid milk (%)	29	15.7	
Sales of yogurt (%)	8.3	14.4	*
Sales of cheese (%)	50.4	57.6	
Sales to final consumers (%)	32.7	34.8	
Sales to hospitality (%)	22.6	18.9	
Sales to shops (%)	27.7	31.7	
Sales to large-scale distribution (%)	13	14.6	
Number of product references	4.9	6.9	***
Organic farms (%)	16	41.7	**
Sales of organic products (%)	8.8	41.4	***
Sales of products with PDO (%)	18.3	26	
Number of workers on the farm	5	4.7	
Processing & marketing workers[1]	66.6	57.7	
Family workers (%)	52	66	
Sales of dairy products/Investment (€)	1.18	1.38	*

Note. [1]Percentage of total workers. *** significant difference at 1% level, ** significant difference at 5% level, * significant difference at 10% level

Discussion

A consequence of a more open and competitive EU dairy market has been the development of new initiatives in order to incorporate value-added into the production of farms, including the elaboration and commercialization of different dairy products such as liquid milk, cheese, yogurt and others. This study explores the effect of intangible resources and capabilities on the performance of these value-added ventures using original qualitative data from forty-nine

Spanish farms obtained through in-depth interviews. We applied a BSC framework in order to articulate the links among intangible resources, capabilities and performance, and thus describe the value creation process in these ventures.

We used a qualitative measure of performance where the firm compares itself to competing firms within the same industry. This measure is based on farmer's perceptions and represents the present and future success of the business. In this way we overcome some of the limitations of indicators based on accounting data. In accordance with previous studies of the farm sector (Skuras et al. 2005; Grande et al. 2011), we decided not to use financial data as part of our study since it was not easily accessible, difficult to standardize, and perceived as being less reliable.

Although there are Spanish dairy farms enrolled in voluntary record-keeping programs conducted by cooperatives and regional governments, these systems provide information about livestock activities but not value-added ventures. Moreover, the farms that have implemented the value-added initiatives are geographically dispersed and heterogeneous in their production systems and in market orientation, which makes it difficult to implement a specific record-keeping system.

However, the design and implementation of a management accounting system would be of great help when it comes to performing benchmarking processes, based on technical and homogeneously-calculated economic indicators (revenue, variable costs and contribution margins for each product, revenues and unit costs of the products according to the distribution channels, overheads, production capacity and level of use of production capacity, etc.). These financial indicators would be useful for studies about farm venture success.

Our results show that knowledge management, the application of MCS and the value proposition to customers have a positive effect on performance, while networks and the technological level did not generate the expected effects. Knowledge management is a basic factor in the success of these ventures, so farmers, advisers, governments and different entities interested in them should favor training and learning processes in the dairy sector. This will contribute to positioning products attractively for customers as well as promote the efficient use of resources. Our results also identify weaknesses in the process of value creation of these farms, such as networks and technology, which should be analyzed in greater depth.

Although networks have a positive effect on internal processes, they do not significantly affect customers or performance. It seems that these farms should improve networks, which would help meet customer needs and increase business profitability. However, farmers frequently mentioned future projects containing new platforms aimed at improving marketing processes; exports and marketing via the Internet, which until now carried little weight in the farms. Similarly, farms dedicated to the production of cheese (certain PDO) with an important number of producers revealing a degree of disappointment because marketing strategies based on price cuts subsequently eroded profits. Likewise, although marketing agreements with large-scale distributors enable higher production volumes, they are accompanied by a perception that sales concentrated on a reduced number of important customers impose certain risks. Moreover, large distributors exert downward pressure on selling prices as compared with those obtained by direct sales to final consumers.

In Spain, cooperatives have a limited role in the transformation and commercialization of dairy products, with a market share of about 21% of the total milk processed (Sineiro and Vázquez 2014). With an aim at improving the effect of networks on the performance of value-added ventures, we understand that cooperatives face future challenges gaining prominence in marketing local dairy products. Furthermore, cooperatives could boost exports of these products.

Technology is relevant in producing and commercializing products which fulfil attributes valued by consumers. Nevertheless, investments in technical resources do not always ensure positive returns. Our results justify the role of technology in developing the value proposition to customers (positive effect: technology → customers) but we also observe an adverse effect on performance (negative effect: technology → performance), which could be related to an excess of productive capacity. In this regard, it was shown that ventures with lower performances also made lower sales per invested euro. Furthermore, despite investments in technology, not all ventures are successful—possibly because work force proficiency occurs over time.

Among the reasons accounting for the negative impact of technology on performance include: the existence of firms with sales levels inferior to their break-even point; the existence of substantial investments with a reduced level of use (excess capacity); and business models based on products and marketing channels with reduced profit margins. One such case concerned the sale of liquid milk via vending machines, requiring major investments. Farmers expressed serious doubts about the feasibility of this type of business.

Conclusions

Diversification via processing and direct marketing is one strategy that farmers can utilize to survive and maintain competitive positions in the global dairy market.

Building on the RBV, this work contributes to the literature using BSC as the conceptual structure to analyze the explanatory factors of performance through a sample of Spanish dairy farms which diversify their activities via production and product marketing.

Findings suggest that a differentiated value proposition, knowledge management and the use of MCS all have a positive effect on performance. A value proposition focused on quality products, coming from a specific geographic area, responding to the highest levels of environmental responsibility, and covering the attributes demanded by the consumers of this type of product contributes in a relevant way to the economic success of these ventures. Knowledge management is an important factor for organizing internal production and management processes with which to satisfy the customers value proposition and, ultimately, to achieve the economic objectives.

Our empirical analysis reveals that courses of action are needed to increase profits through improved technology and networks. According to the perceptions of farmers, the level of technology in the context of production and organization does not affect performance significantly, when considering the total picture. Something similar occurs with networks, which do not appear to have a significant effect on performance. Actually, the study adds to findings from previous research that networks can be very challenging (Grande 2011), or even prejudicial if relationships established are inequitable (Blundel 2002).

The reasons why technology and networks fail to contribute to economic success must be identified in order to find solutions. Therefore, new diversification initiatives in the dairy sector should pay special attention to obtaining technology which can be capitalized, as well as securing networks that can contribute towards improving performance. Excess capacity could be properly managed through agreements with other producers, suggesting the need to create networks that contribute to profitable investments in technology.

For management scholars, this study underlines the value of BSC as framework in order to articulate the links between those intangible resources and capabilities, that previous research suggest play an important role in the economic success of agricultural diversification. The results are consistent with a ‘complex’ value-creation process (Bryant et al. 2004), revealing a large variety of significant relationships among the factors contemplated. The results also support the ‘simple’ value-creation process represented by the hierarchical formulation of BSC (learning and growth → internal processes → customers → performance).

The results of this work can prove useful to entrepreneurial farmers, advisers and public administrations interested in promoting diversification initiatives. New diversification projects should be subjected to an appropriate feasibility study which contemplates all the relevant factors for its economic success, proposing business models which consider differentiation in an explicit way, through intangible resources and management abilities (customer value proposition, knowledge management, MCS, networks). In the design of new value-added ventures, farmers have to understand and pay attention to the links among all four BSC perspectives in order to not compromise the future feasibility of these initiatives.

Public policies to support farm diversification initiatives should not be restricted to investment in facilities and technology. In light of our results, these policies should also cover intangible resources and core competencies to achieve success in these ventures.

Finally, this work suffers from a number of limitations and possible lines of development exist that should be considered in future research. The sample size is small and refers to only one year, and therefore the results should be interpreted with due caution. On the other hand, the variable for performance has been measured qualitatively, employing the perception of the entrepreneurs with respect to the achievement of economic objectives. Future work should investigate in greater depth the study of economic results measured using different quantitative variables (ROI, ROE, Productivity). This requires the construction of accounting data bases based on homogeneous criteria, currently unavailable, which are crucial to developing benchmarking processes in order to improve the performance of these ventures. In the same way, further research is needed on how these farms use technology and networks in order to generate competitive advantage and explain what the weak points of this process may be.

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China as Dairy Importer: Rising Milk Prices and Production Costs

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Abstract

China's emergence as a major importer of dairy products corresponds to rapid increases in its domestic milk prices. Allocating growth in China's milk prices from 2006 to 2014 to production cost categories shows that feed concentrates and fodder account for about half of the price increases. While labor productivity grew rapidly, there was only moderate growth in milk per cow and no improvement in milk output per unit of feed. Scarcity of feed resources, particularly forage, is likely to constrain growth of China's milk production and maintain the country's demand for dairy imports.

Keywords: China, dairy, productivity

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Introduction

Seven years after the melamine crisis, China's Agriculture Minister said that consumers still lacked confidence in Chinese dairy products (Han 2015). He also raised concerns that resource scarcity and pressure from low-priced imports constrained the industry's development. Industry analysts also stressed the importance of supply-side issues. Li (2015) cited low productivity of cows, feed conversion, and disease control as major problems facing the industry. Gai and Gao (2015) emphasized the need to improve competitiveness by increasing the scale of producers and strengthening their linkages with processors. Li (2015) also observed that imported alfalfa had become a key input for China's large-scale dairy farms, given the scarcity of forage resources in China.[1]

While it is apparent that supply-side factors are important determinants of China's demand for imported dairy products, there is little recent analysis of these factors. Zhou, et al. (2010) warned that the expansion of large-scale dairy farms had outpaced feed supplies, improvements in manure disposal, and disease control. Wang and Li (2014) found only modest differences in milk yield per cow across different sizes of dairy farms and concluded that rising labor and feed costs were the main factors driving the exit of small-scale farms. More investigation of the changing cost structure of China's dairy industry is needed to assess the country's prospects for meeting its growing consumption of milk products.

This article analyzes the cost structure and measures of partial productivity for different sizes of dairy operations to gain insight about the international competitiveness of dairy production in China. The analysis assesses the contribution of various components of production costs to rapid growth in Chinese milk prices. Growth in input prices and partial productivity measures is considered to evaluate the role of input scarcity in constraining growth of China's dairy sector.

The next section describes the analytical approach and cost of production data used for the study. The analysis that follows profiles recent growth in Chinese milk prices and key input prices. It then reports changes in cost components and partial productivity measures for different types of farms. A final section summarizes the findings.

Analytical Framework and Data

This analysis investigates recent trends in milk prices, unit milk production costs and partial productivity measures of Chinese dairy farms to gain insight about how the industry is evolving. In view of the rapid structural shift from small "backyard" farms to large-scale farms in China's dairy industry, the analysis is conducted for farms of varying scale.

The demand for imports of a commodity by a country is driven by growth in the commodities consumption and the capacity of domestic producers to supply it. Domestic prices tend to rise when consumption growth outpaces growth in domestic supply, prompting increased demand for imports when domestic price exceeds the price of imported supplies. Limited supplies of inputs

[1] According to China's customs statistics, imports of alfalfa (Harmonized System code 121409) rose from 77,000 metric tons in 2009 to 1.36 million metric tons in 2015.

may drive input prices higher, contributing to growth in a commodity's output price. However, the effect of rising input prices on output price may be offset by increases in the productivity of inputs.

The relationships of input prices and partial productivity to output price are implied in the basic identity that revenues to producers are fully distributed to input costs and net returns:

1) $PQ = \sum_{i=1}^{K} w_i x_i + NR$

where P and Q are the price received and the quantity produced of output (milk), w_i and x_i represent the prices and quantities of each of K inputs such as labor and feed, and NR is the value of net returns to management.

The change in the output price over time equals the sum of changes in per-unit input costs and net returns per unit of output:

(2) $\Delta P = \sum_{i=1}^{K} \Delta \left(\frac{w_i x_i}{Q}\right) + \frac{\Delta NR}{Q}$

Changes in output price could be influenced by both changes in input prices and productivity of inputs. If a competitive industry with low barriers to entry and exit maintains a given level of net returns (ΔNR=0) in the long run, and the average product is represented by $AP_i = Q/x_i$, then equation 3 results:

(3) $\Delta P = \sum_{i=1}^{K} \frac{\Delta w_i}{\Delta AP_i}$.

An increase in input prices—wages, land rents, feed and input prices—could be offset by increases in average output of milk per unit of input. If input prices rise faster than productivity, China's milk price will have to rise to maintain profitability.

The data for the empirical analysis is obtained from a cost of production survey conducted by China's National Development and Reform Commission (NDRC). The survey was developed during the 1970s as a tool to aid officials in setting farm prices, and it is still conducted annually. The data is widely used by analysts in China, and it was the basis for research by Fuller et al. (2006), Rae et al. (2006), and Wang and Li (2014).

The NDRC survey is conducted by a hierarchy of planning commission offices and statistical bureaus at the national, provincial, and county level. Participating farms are chosen at the discretion of county officials under guidelines issued by administrators. Officials are instructed to choose farms from representative townships in their jurisdiction that represent various sizes and types, but there does not appear to be a rigorous standard procedure for selecting sample farms. Farmers record data on expenses, production, sales and input use, and submit the report form to the office. The data are compiled and reported to provincial and national offices. NDRC publishes an annual compilation of tables showing average expenses and quantities for dairy and other commodities. No sample sizes or standard errors are published, so the reliability of the data is hard to assess.

While the survey design does not appear to be rigorous, the data are a unique compilation of information useful for tracking changes in income and expenses of farms in China over time. Examination of the data bolstered our confidence in the reliability of data for 2006–2014 which was tabulated in a manner consistent with other data sources and market reports.[2]

Each year from 2006 to 2014, the NDRC published a table showing average expenses for four types of dairy operations: "backyard" (1–10 head), "small scale" (11–50 head), "medium scale" (51–499 head), and "large scale" (500 head or more). NDRC reported physical quantities of milk per cow, labor input, and feed concentrates (referred to by NDRC as "fine" feed) and expenses for other items. NDRC also reported the average producer price for milk. The analysis is based on a compilation of data reported in these tables. A weighted average of small scale and medium scale data is calculated to reduce the number of categories.

Rapid structural change in China's dairy industry is evident from Ministry of Agriculture data showing shares of dairy cattle by size. The share of cows held by smallholders with less than 5 head fell by more than half, from 44.8% in 2002 to 21.8% in 2013. Small-scale farms holding 5–19 head increased their share slightly from 2002 to 2008, but their share of cattle fell by 10 percentage points from 2008 to 2013. The changes in shares reflect a large decline in the number of backyard smallholders and rapid increase in the number of large-scale farms. The data reveal rapid consolidation that is important to consider when analyzing farm costs and productivity.

Table 1. Share of dairy cattle by farm size, 2002–2013.

Size of Farm	2002	2008	2013
Number of Cows		*Percent*	
1 – 4	44.8	32.4	21.8
5 – 19	29.3	31.5	21.2
20 – 199	17.6	20.5	21.7
200 or more	8.3	15.5	35.3
Total	100.0	100.0	100.0

Source. China Ministry of Agriculture

Trends in Chinese and US Dairy Prices

The analysis begins by comparing trends in milk prices using cost of production survey data for China and the US over 2006–2014 to provide context for the analysis of costs. The average price reported by the NDRC data was converted to dollars per cwt at the official exchange rate for each year. The US milk price, reported by US dairy farm cost-of-production estimates, is reported annually by the USDA (McBride 2016).[3]

[2] NDRC data from the early 1990s and 1980s was reported in varying tabulations, and some indicators displayed large year-to-year fluctuations that undermined confidence in the data's quality for those years.

[3] China's dairy imports consist mainly of powdered milk and other products, but in this analysis we compared farm prices from similar production cost surveys in China and the United States to capture differing cross-country trends in farm-level prices. We also compared imported milk powder prices converted to a fluid milk equivalent with Chinese milk prices and found patterns similar to the comparison reported here.

China's milk price rose faster than the US milk price, suggesting a decline in competitiveness for milk producers in China. In 2006, the China price ($11.09/cwt) was about 15% less than the US price ($12.99/cwt) (Figure 2). The China price rose each year thereafter to reach $29.46/cwt in 2014—about 24% higher than the US price that year. The US price rose in some years and fell during others. The China price exceeded the US price each year from 2009 to 2014, and the difference was as large as 46% during 2013. The rise in the dollar price of China's milk reflects a doubling of the price in local currency plus a cumulative 30% appreciation of the currency against the dollar from 2006 to 2014. The increase in the China price above the US price during 2009–2014 corresponds to the increase in China's milk imports during those years shown in Figure 1.

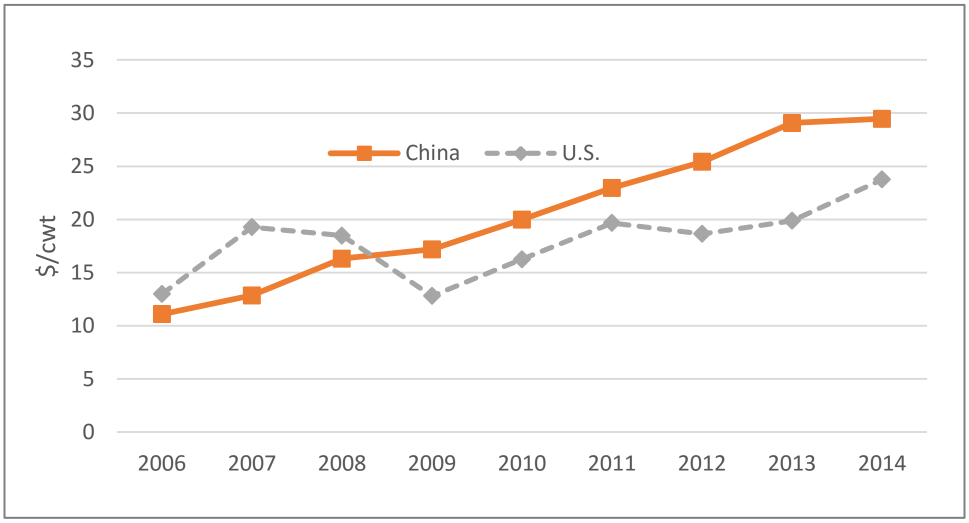

Figure 2. China–US farm prices for milk, 2006–2014.
Note. China milk price is average reported by NDRC. US price is from McBride (2016).

The increases in the Chinese milk price reflect rising costs of production in the country. Indexes were calculated to assess the rise in overall costs and the role of several key input prices. An index reflecting production cost was calculated as the ratio of total cost per kg of milk output reported by the NDRC data to its value in 2009. Similar price indexes were calculated for feed concentrates, hired labor, and imported alfalfa. The average price of feed concentrate was calculated as the ratio of feed expense to quantity of feed used. The average daily wage for hired laborers was obtained directly from NDRC reports. Chinese customs data (Harmonized System code 121490) was used to calculate the unit value of imported alfalfa as a proxy for its price since the NDRC data do not provide quantity information to calculate prices of forage and hay.[4] The alfalfa unit value was converted to Chinese currency at the official exchange rate for each year.[5] The hired labor wage is a cash expense recorded by farms.

[4] Imported alfalfa is a key input for large-scale dairy farms (Li, 2015). Imports rose from 77,000 metric tons in 2009 to 1.4 million metric tons in 2015.
[5] No data on unit values for 2006-08 are available because China did not import significant volumes of alfalfa before 2009.

A simple index with a base year of 2009 was calculated for each value in Chinese currency with no adjustment for inflation. The indexes for total production cost and prices of feed concentrate price, imported alfalfa, and labor are displayed in Figure 3. The total cost index rose each year from 2006 to 2014, with cumulative growth of 91% from 2006 to 2014. Growth in the production cost and the milk price was about three times the general rate of inflation in China—cumulative growth in China's CPI from 2006 to 2014 was 30%. The wage was the fastest-growing input price, with daily wages growing 190% during 2006–2014. The feed concentrate price rose 96%, roughly the same rate as growth in total cost. The price of imported alfalfa rose during 2011, 2012, and 2014 but it declined during 2010 and 2013. The cumulative increase in alfalfa price from 2009 to 2014 was 22%, less than a fourth of the growth in the feed concentrate price. Thus, imported alfalfa became cheaper relative to feed concentrates, consistent with the surge of China's alfalfa imports during those years.

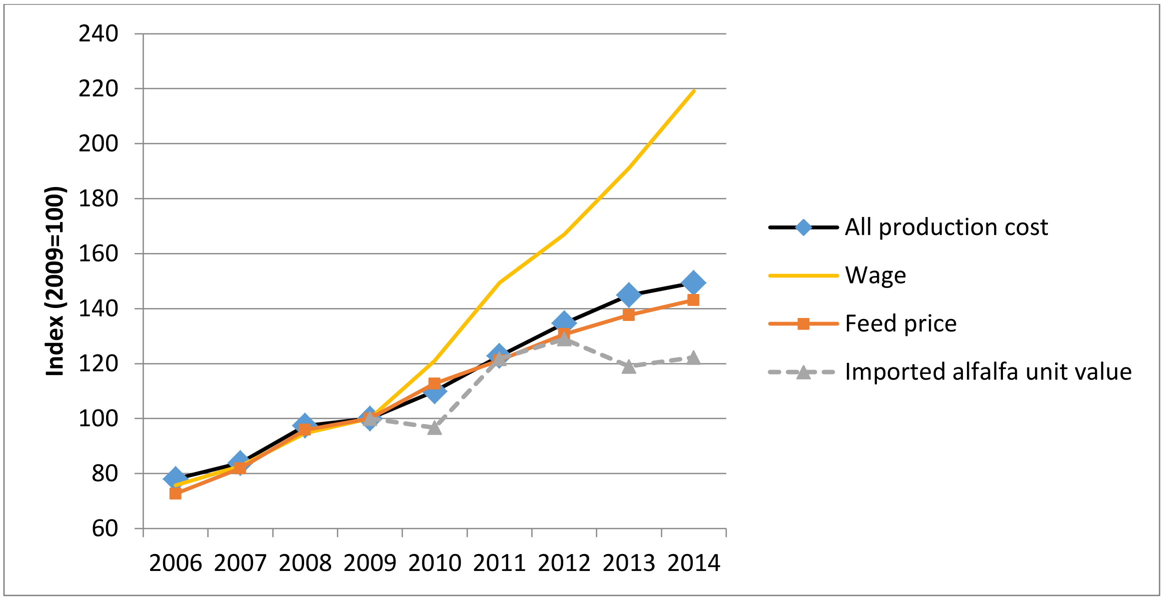

Figure 3. Indexes of China diary input prices and cost.
Note. Production cost is average reported by NDRC. Wage is daily wage for hired workers. Feed price is expense for feed concentrate divided by volume consumed. Imported alfalfa unit value calculated from customs data converted to Chinese currency.

Contribution to Milk Price Growth

The growth in Chinese dairy farms' gross revenue was allocated to expense categories to assess cost factors driving the growth in China's milk prices. Milk sales consistently accounted for 90% to 93% of gross revenue in the NDRC data. Thus, the gross revenue per kilogram of milk output largely reflects the milk price. The source of the remaining 7% to 9% of revenue for dairy producers is not identified, but may include sales of calves, cull cows, and manure.

The per-cow expenses reported by NDRC were converted to expenses per unit of milk output for five categories:

- feed concentrates (referred to as “fine feed”: grains, oilseed meals, beans, bran, commercial feed)[6]
- fodder (“green coarse feed”: hay, grass, corn stalks, and other forages valued at market prices)
- labor (hired labor expense and imputed value of unpaid family labor)
- fixed asset depreciation (dairy cattle and structures)
- Other expenses (total production cost less the four categories above)

The net return to management was calculated as a residual between gross revenue and the sum of the five expense categories.

The cost of both hired and family labor was estimated using the average wage for hired labor. NDRC imputes the value of family labor based on local per capita income statistics. The hired labor wage exceeded the imputed family labor wage by 87% in 2006 and by 27% in 2014, suggesting that the wage imputed for family labor might not reflect the level or the trend in rural wages. Therefore, the wage for hired labor was used to impute the expense of both hired and family labor.[7]

The analysis was conducted for three dairy operations: backyard (1-9 cows), small-medium scale (10-499) and large scale (500 or more cows) farms to provide perspective on the structural shift from small- to large-scale farms. Table 2 displays the increases in gross revenue, five categories of expenses, and returns to management from 2006 to 2014 for each of the three operations. Consistent with the increase in price observed previously in Figure 2, the gross revenue per unit of output increased each year from 2006 to 2014 for each type of producer. The cumulative increase in gross revenue was 2.20 yuan/KG for backyard farms, 2.22 yuan/KG for small-medium farms, and 2.49 yuan/KG for large-scale farms. Expenses and net returns also increased each year to varying degrees. However, revenue grew faster than overall expenses, so the residual net returns grew for each type of operation. The increase in net returns is inconsistent with anecdotal accounts of low profitability in the sector. This could reflect under-reporting of some expenses, as discussed below.

Feed concentrate was the leading contributor of expense growth for both backyard and large-scale farms. The feed concentrate expense absorbed 36.3% of the increase in revenue of backyard farms, 33.5% for small-medium farms, and a 30% share for large farms. In contrast, fodder expenses were more important for large farms (20.6%) than for small-medium (16.4%) and backyard farms (11.8%). The greater fodder share for large farms likely reflects the greater propensity of farms with large numbers of cows to purchase high-quality fodder and transport it to a fixed location. Backyard farmers often gather fodder locally or graze their few cows near their farmstead.

[6] According to NDRC documentation, feed expense does not include that used for calves and replacements.
[7] “Backyard” farms use almost exclusively unpaid family labor while large scale farms use mainly hired labor, so using the same wage for both types of labor also removes a potential bias in evaluating labor costs of different sizes of farms.

Table 2. Contribution of expenses and net returns to 2006–2014 milk price increase, by farm type.

	Backyard Farms (1–9 Cows)		Small-Medium Farms (10–499 Cows)		Large Scale Farms (500 or more Cows)	
	2006–2014	Share of Increase	2006–2014	Share of Increase	2006–2014	Share of Increase
Item	*Yuan*	*Percent*	*Yuan*	*Percent*	*Yuan*	*Percent*
Gross income	**2.20**	**100.0**	**2.22**	**100.0**	**2.49**	**100.0**
Feed concentrate	0.80	36.3	0.74	33.5	0.75	29.9
Fodder	0.26	11.8	0.36	16.4	0.51	20.6
Labor	0.44	20.0	0.34	15.2	0.20	8.0
Depreciation	0.07	3.1	0.16	7.4	0.20	7.9
Other expense	0.03	1.3	0.03	1.5	0.13	5.0
Returns to management	0.61	27.6	0.58	26.0	0.71	28.6

Note. Table shows change in each value from 2006 to 2014 with no adjustment for inflation. The sum of increases in expenses and returns to management equal the increase in gross revenue.

Conversely, labor expense was more important for backyard operations than it was for large-scale farms. Labor expense absorbed 20% of revenue growth for backyard farms, 15.2% for small-medium farms, and only 8% for large-scale farms. This pattern reflects greater labor intensity of small-scale production.

Depreciation was a more important expense for large farms (7.9% of revenue growth) and small-medium farms (7.4%) than it was for backyard farms (3.1%). This may reflect minimal investment in facilities and high-quality cows by backyard farms. Depreciation of fixed assets may be understated since many Chinese farms have benefited from subsidies for construction of "scale" farms or "dairy-farming communities" (known in Chinese as *yang zhi xiao qu*). Higher expenses for other items like veterinary fees, manure disposal, and energy may be reflected in the greater share of other expenses (5%) for large-scale farms versus small-medium farms (1.5%) and backyard farms (1.3%).

Residual returns to management accounted for a surprisingly large share of the increase in milk prices—26%-28% for the three types of farms. This result is at odds with phenomena that indicate low profitability such as exit of backyard farmers and reports of "milk dumping." The apparent increase in net returns shown by the NDRC data may be an artifact of undervaluing unpaid family labor, self-supplied forage resources, or understating land cost. Depreciation expense could be understated by NDRC's assumption of a relatively long six-year productive life of cows.

Partial Productivity Measures

Increases in input prices can potentially be offset by increases in productivity to maintain price- and cost-competitiveness. In the second part of the analysis, growth in partial productivity is assessed for three main inputs for which physical quantity data published by NDRC: the number of cows, feed concentrate use, and days of labor input. Growth in milk output per unit of input was calculated for each input from 2006 to 2014 for an (unweighted) average over all farms reported by NDRC.[8]

Indexes of milk output per cow, milk per unit of feed concentrate, and milk per day of labor were calculated with the 2006 value set equal to 100 as the base year. Calculations were performed for each of four farm size classes which displayed similar trends. The results are summarized two tables showing how productivity grew over time and differences across farm size classes.

Table 3. Partial milk productivity indexes for Chinese dairy farms, 2006–2014.

Year	Cows	Feed Concentrate	Labor
		2006=100	
2006	100.0	100.0	100.0
2007	101.7	100.0	106.6
2008	103.1	100.3	109.7
2009	105.6	101.4	122.1
2010	103.9	100.0	121.3
2011	104.1	103.7	122.2
2012	105.1	100.7	125.6
2013	106.1	100.9	129.7
2014	106.4	99.3	130.3

Note. Table shows indexes calculated based on milk output per cow, per kg of feed, and per day of labor reported in NDRC data for all dairy farms.

Labor was clearly the input with the greatest improvement in productivity over time (Table 3). Output per labor-day rose a cumulative 30% from 2006 to 2014. However, the growth in labor productivity was uneven, as most of the increase occurred during 2006–09. Milk per cow grew only marginally—a cumulative 6.1% from 2006 to 2013, or less than 1% annually. There was essentially no change in milk per unit of feed concentrate during 2006–2013 and feed productivity dropped in 2014.

The dominance in labor productivity growth is consistent with adoption of labor-saving technology or business models induced by the rapid rise in wages. The 30% improvement in labor productivity only partially offsets the 90% increase in wages reported earlier in Figure 3. While improvement in labor productivity was not fast enough to fully offset the rise in wages, it did mute the impact of rapid wage growth on the rise in labor cost. The analysis of costs presented above found that labor accounted for 20% of revenue increase for backyard farms and just 8% for large-scale farms.

The comparison of productivity by type of farm suggests that the Chinese dairy industry improved productivity by shifting from backyard farms to large-scale farms. The differences in

[8] Data on output by size class were not available to calculate weighted averages. The Ministry of Agriculture's Livestock Industry Yearbook reported cow inventories by size for 2008 but not for more recent years.

productivity across farms is summarized by calculating partial productivity indicators for each farm type using averages for 2006–2014 and calculating an index with backyard farms equal to 100 (Table 4).[9] The indexes show that productivity of each input increases with farm size. Small, medium, and large-scale farms all have more productive laborers and cows than backyard farms (Table 4). Milk-per-cow of large-scale farms is 23.2% higher than that of backyard farms, while the advantage over backyard farms is 8.4% for medium-scale farms and less than 1% for small-scale farms. There is little difference in milk-feed ratios across farm types. Feed productivity was about 2–4% higher for small, medium and large farms compared with backyard producers. Labor productivity differs dramatically across farm types. Labor productivity on large farms is more than double that of backyard farms. Small-scale farms labor productivity is 35.7% higher than that of backyard operations. For medium-scale farms the labor productivity advantage is 63.4% and for large scale farms it is 116.7%.

Table 4. Partial productivity comparisons by type of dairy farm, 2006–2014.

	Type of Farm			
Input	**Backyard**	**Small**	**Medium**	**Large**
		Backyard farm = 100		
Cows	100.0	100.9	108.4	123.2
Feed	100.0	102.5	103.5	104.2
Labor	100.0	135.7	163.4	216.7

Note. Table shows indexes based on average milk output per cow, per kg of feed, per day of labor. For each input, the index shows the productivity compared with backyard producers. Indexes are averages over 2006–2014.

Conclusions

China's dairy industry is encountering obstacles to growth as it expands to meet the country's growing demand for dairy products. Inputs are becoming scarce and their prices are rising rapidly as demand grows. Cost pressure from rising input prices and an appreciating currency have contributed to higher milk prices in China which corresponds to rising wholesale prices for dairy products in China. The rise in milk prices during 2009–2014 corresponded to China's emergence as a significant importer of dairy products. China is likely to remain a significant importer if cost pressures continue to push its milk prices above international prices.

Based on analysis of the cost structure of Chinese dairy producers, scarcity of feed resources may be a key obstacle to expansion of China's dairy industry. China's high cost of corn and other feed grains is an impediment to expansion of its dairy sector. The analysis also reveals the importance of fodder in the cost structure of large scale farms. Large concentrations of cows cannot easily be grazed given the large land requirements. Instead, large farms tend to rely on purchasing hay and other forages.

Transition to larger-scale farms may achieve greater technical efficiency, but higher costs of fodder and scarcity of skilled laborers and farm managers may impede competitiveness and

[9] There were no discernible differences in trends in the productivity measures across farm types, so we only report the index by farm type for the average over 2006-2013.

expansion of domestic dairy output. Large-scale farms also require higher investment in fixed assets and expenses for veterinary services and manure disposal.

China's trade policy sets low tariffs for imports of scarce high-protein feed ingredients like soybeans and alfalfa which has allowed livestock producers to circumvent resource constraints to some degree by importing those scarce feed resources (Gale 2015). The shift to large-scale farms coincided with China's rising imports of alfalfa which may have been encouraged by low import prices compared to local feed prices. In contrast, China's grain prices were kept artificially high by a price support program and an import quota for corn during 2006–2014. The elimination of China's corn price support program announced in 2016 could relieve some cost pressure if corn prices fall, but the import quota for corn is likely to continue. A Ministry of Agriculture plan to shift land from corn for grain to corn silage, alfalfa and other fodder crops may also support dairy production by adding to domestic feed supplies.

While the corn policy adjustments may slow the growth of feed costs, the across-the-board increase in production costs observed in this study suggests scarcity of other inputs may also constrain the dairy industry's growth. In view of continuing constraints on domestic output growth, China's rising consumption of dairy products is likely to be satisfied to a significant degree by imports. Thus, China is likely to grow as an export market for dairy products.

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Dairy Export Markets: Changing the Structure of US Dairy Demand

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Abstract

The role of the United States in international milk and dairy product markets has changed significantly in recent years. Although it seemed unexpected, the foundation for that change was laid following the 1994 signing of the Uruguay Round of GATT. The first decade of the 21st century also saw some important changes in the United States and in major dairy exporting areas around the world. Exploratory statistical analysis is undertaken to support assertions. There is at least some evidence that pre- and post-Uruguay round implementation periods are significantly different with respect to trade indicators. These preliminary findings suggest several avenues for further analysis.

Keywords: dairy trade, milk, supply and demand, international trade, trade agreements

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Introduction

A major dairy industry storyline in 2014 was the changed role of the United States in international milk and dairy product trade. The US had become the third largest supplier of milk and dairy products to international markets with a 14% share. New Zealand held the top position with a 38% share and the European Union (EU) was in second place holding a 32% share (Dairy Australia 2015). Although it had the feel of an overnight development, the foundations for changes in the US dairy industry's approach to international marketing were laid in the late 1990s and the first decade of the 21st century.

In the five years prior to 2000, the exported share of US milk production (on a total milk solids basis) was relatively stable at about 3.1%. The share rose to about 4% from 2000 to 2003 before growing to 15.2% in 2014. There has been only one major downturn in the export growth since 2004, the 2008–2009 period coinciding with the global recession. The more remarkable fact to note is how quickly exports rebounded to even higher levels after the downturn (Figure 1). It is clear that dairy businesses and companies in the United States have more actively delivered their products for commercial export.

A second thing to note in Figure 1 is that US dairy imports have been a smaller share of production since 2003. After rising to about 4% in 2005, imports declined to shares representing between 2–3% of production since 2010. However, the United States is still an inviting market for exporters of milk and dairy products around the world, particularly for cheeses.

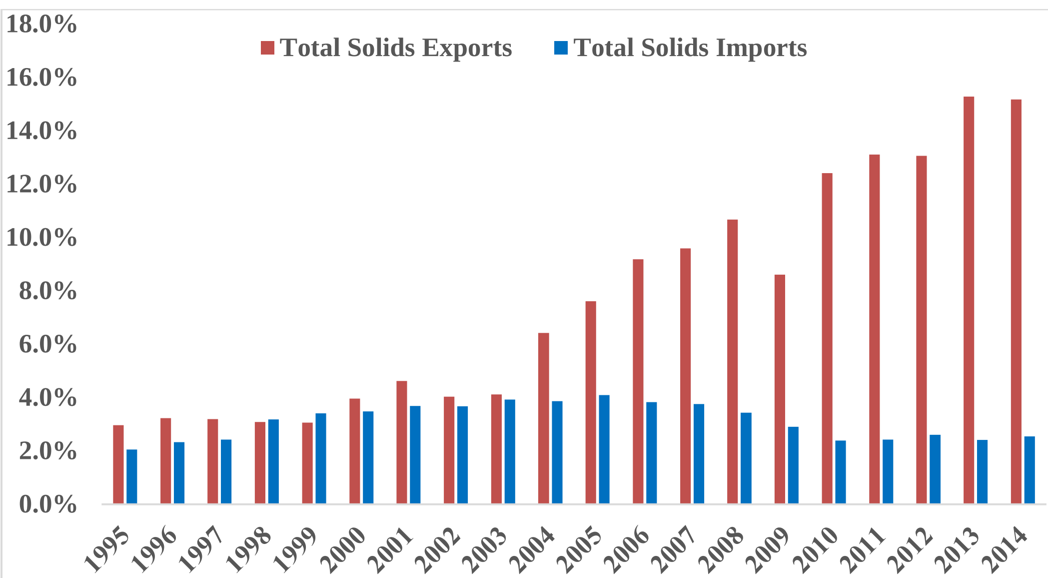

Figure 1. Annual export and import of total solids as share of total solids production, US.

The aggregate demand for milk and dairy products in the United States, and in dairy trading nations worldwide, is comprised of two components: domestic demand and demand for exports. The growth in the export component in the United States suggests there has been a structural change in aggregate US dairy demand. That is, the interactions between or among the US domestic dairy product market demands and dairy product export demands have changed. But demands for US milk and dairy products are only half of the story; milk production and supply factors must be considered also. A short digression examining the US milk supply and use, sets the stage for the demand relationships that are examined later. This quick diversion to supply issues also provides the opportunity to explain the framework for calculating demand estimates such as those shown in Figure 1 and others to be considered in following sections.

Milk Supply and Use in the United States

Dairy farm operations in the US have grown larger, production costs have come down and productivity (milk per cow) has increased over time. Technological advances on the farm have been major drivers of these changes, but so too have forces beyond the farm gate. Among those forces are changes in US domestic dairy policies and programs, evolving environmental regulations, consumer evaluations of milk and dairy products related to diet and health, and changing agricultural trade policies.

Milk production and use estimates are provided by USDA based on accounting frameworks known as Supply and Use (S & U) and Commercial Disappearance and the units of measure are milk equivalents, or milk components.

Milk equivalents define the elements of S&U or commercial disappearance in the units matching the farm milk production, commonly reported in volume-based terms like hundredweights (cwt) or pounds. Milk components are the two solid components in milk; milkfat and solids not fat (SNF). The two solids constitute about 13% of each 100 pounds (cwt) of milk produced. Solid contents are determined by testing milk produced. The solids do vary by dairy cattle breed, across regions of the country and seasonally.

Annual commercial disappearance data for the 1995–2014 period in terms of milk equivalent, fat basis is shown in Table A1 (see Appendix). Milk production is shown growing by almost 33% from 1995 to 2014 as commercial exports grew by over 300%. The production change is similar to the 36% production change derived using the total solids as in Figure 1 but there is a significant difference in the commercial export changes (300 compared to 600%). The take-home point of this exercise is that the units of measurement, despite being different, are describing the same underlying situation.

About 56% of US milk production in 2014 was manufactured into cheese and cheese-products. This product share, and others like it, is derived using product milk equivalent factors to convert the products to fluid form that are then compared to the total milk production. Cheese manufacturing generates a co-product that has become more economically important in its own right, liquid whey. Liquid whey can be processed into differentiated products with functional properties meeting the needs of many product producers, including food producers. Those products include dry whey, whey protein concentrates, modified whey, and lactose.

Fluid milk products processing and packaging absorbed the second largest share, about 25%. The quantities of milk used in fluid milks (also called beverage milks) has declined steadily over the last several years. The remaining 19% of production is used to produce all of the other milk and dairy products supplied. A relatively recent trend among these other products has been growing yogurt production.

Domestic US Dairy Product Demands

Milk equivalents and milk components can be used for analysis of dairy demands but a third possibility, and one more understood by the general populace, is to examine individual manufactured or processed dairy products. Consumers, especially individuals or in households, are more likely to grasp demand issues as they affect specific products they have in their homes. Also, analyses of food demand often focus on income, which is commonly reported in per capita or per household form, as a key demand determinant.

As Table 1 shows, US per capita domestic demand for all dairy products measured on a milk equivalent, fat basis has grown about 4% from 2000 to 2014. The demand trends for the selected individual products vary but in the US, cheese product demands have been a driving force behind overall dairy demand growth for many years.

Per capita natural cheese consumption increased from 30.4 pounds in 2000 to about 34.1 pounds in 2014, about 12.2%. A USDA report in 2010 (Davis et al. 2010) suggested that cheese demand might be slowing as population characteristics in the US changed. The annual percentage change in per capita cheese consumption did slow from 1.4% between 2009 and 2010 to 0.4 % between 2012 and 2013. However, the growth rate then rebounded markedly from 2013 to 2014 (1.6 %).

The per capita consumption of fluid milk, based on estimated sales, declined from 196 pounds to about 159 pounds (slightly over 19%) from 2000–2014. The fluid beverage milks include whole, reduced fat milks, flavored milks, buttermilk and a miscellaneous, each having different consumption trends over time. Total beverage milk consumption has declined for many years, but the year-over-year changes in more recent years have increased (from -0.6 % from 2009 to 2010 to -3.7 % from 2013 to 2014).

Reduced fat ice cream has been relatively steady since 2000 but regular ice cream demands have declined, perhaps an indication of changing health concerns. In general, ice cream is a product that is popular regardless of any other existing conditions or demand factors. Butter demand actually increased somewhat but has steadied in recent years and the demand for nonfat dry milk, not a major consumer product, has moved up and down but at generally low levels.

A product not shown in Table 1 that has gained importance for the US dairy industry is yogurt. Its production and consumption growth in recent years suggests that yogurt will be an important factor in the US domestic dairy market going forward. Nutritional and health benefits are an important component of efforts to increase demand for yogurt products. There have been some recent efforts to examine demand for yogurts and those efforts will only improve as both production and demand data for the various products become available.

Table 1. Selected dairy products: Per capita consumption in pounds, United States, 2000–2014 [1]

Year	All products [2]	Fluid milk and cream[3]	Butter	American cheese	Other cheese	Regular ice cream	Reduced fat ice cream	Nonfat dry milk
2000	590	196	4.5	13.5	16.9	15.6	6.0	2.7
2001	586	193	4.3	13.6	17.0	15.3	6.0	3.3
2002	589	191	4.4	13.6	17.4	15.7	5.3	3.4
2003	596	189	4.5	13.2	17.7	15.4	6.2	3.3
2004	595	186	4.5	13.5	18.1	14.1	5.9	4.7
2005	603	185	4.5	12.8	18.7	14.6	5.5	4.0
2006	612	184	4.7	13.2	19.1	14.8	5.7	2.8
2007	612	181	4.7	12.9	19.9	14.3	5.7	2.8
2008	607	179	5.0	13.3	19.1	13.8	5.7	3.0
2009	607	178	5.0	13.4	18.9	13.5	5.9	4.0
2010	603	177	4.9	13.9	19.4	13.5	6.0	3.2
2011	603	174	5.4	13.7	20.0	12.8	6.0	3.0
2012	613	170	5.5	13.3	20.2	12.8	6.6	3.7
2013	605	165	5.5	13.4	20.3	12.8	5.9	3.0
2014 [4]	614	159	5.4	13.5	20.6	12.3	6.1	3.1

Sources. USDA , U.S. Department of Commerce Bureau of the Census, California Department of Food and Agriculture.
[1] Based on total population except for fluid products (resident population), July 1 estimate.
[2] Milk equivalent, milkfat basis
[3] Product weight of beverage milks: whole, reduced fat, low fat, skim, flavored, buttermilk and miscellaneous.
[4] Preliminary

Dairy Export Demands Grow

Several key events from 2000 to 2014 period have played a role in propelling the United States toward pursuing opportunities as a commercial dairy exporting nation:

- Final implementation of Uruguay Round Agricultural Agreement (URAA) commitments by the US and other major dairy trading nations (2000);
- China's accession to the WTO (2001);
- A "perfect storm" of drought in Australia and New Zealand in 2006/2007 that coincided with reductions in subsidized exports from the EU;
- The last North America Free Trade Agreement (NAFTA) transitional agricultural trade restrictions were removed (2008);
- Relatively quick recovery of US commercial dairy exports after the 2008–2009 global recession; and
- On-going participation in bi-lateral and multi-country trade talks such as the Korea–US Free Trade Agreement (KORUS), the Trans-Pacific Partnership (TPP) and the Transatlantic Trade and Investment Partnership (T-TIP).

The URAA for the first time put national dairy import rules on a relatively common, and more transparent, tariff-based system. The individual tariff rate quota (TRQ) systems that evolved and were added to already existing tariffs created issues for some trade negotiators, but they remain in place (Skully ERS 2001). Further, part of the URAA commitments were reductions in subsidized exports and increasing imported product access to domestic consumer markets (Peterson 2015).

The accession of China to the WTO in 2001 changed the accessibility for all agricultural product exporters to a huge market. The Chinese initially focused on implementing domestic policy changes that had been under way since the 1980s while committing to reduce agricultural tariffs, eliminate export subsidies, limit potentially trade distorting domestic crop supports, and address sanitary and phyto-sanitary regulations based on sound science (Conklin 2002; Gale, Hansen and Jewison 2015). A central element of China's WTO commitments was to put in place a system of TRQs for many major agricultural commodities.

When concerns related to melamine contamination of infant formula arose in 2008, Chinese dairy product imports rose substantially. China became, and remains today, an important market for dairy product exporters as income growth in the country has changed consumers' food demands. The United States was the second largest exporter of dairy products to China over 2012–2013 with a 10% share valued at $4.2 billion (Gale, Hansen and Jewison 2015). However, the recent slowing of China's economic growth has reduced the flow of dairy imports.

Prior to the middle of 2006, the EU and Oceania (New Zealand and Australia combined) dominated international commercial dairy product markets. Australian dairy policy was significantly reformed in 2000, and during 2006–2007 both Australia and New Zealand endured severe weather conditions that significantly reduced milk production in both countries. At the same time, budgetary pressures in the EU, but not policy changes, were reducing the EU's ability to subsidize dairy product exports. Taken together, the two events reduced quantities of dairy products available to international markets. Buyers that normally obtained EU or Oceania dairy products were likely forced to find alternative sources to meet their immediate needs; and the United States was able to respond.

The United States had supplied international dairy markets before and had, after the immediate need for products was met, usually lost interest in them. The 1994 signing of NAFTA and the finalization of its rules in 2008 brought agricultural product markets in the US, Mexico and Canada into closer alignment, but not for all product sectors.

Mexico has been and still is a major market for nonfat dry milk (NFDM). Prior to 2006, Liconsa, a government enterprise that provides nutritional assistance to low-income Mexican households, was the primary buyer of US–NFDM. However, it has changed its emphasis to purchasing and distributing domestically produced fluid milk products (Zahniser et al. 2015). There have also been consistent exports of consumer products from the United States to Mexico of fluid milk, butter and cheese as well.

Canada, which under the NAFTA structure has maintained its use of a milk supply management policy and the associated protections in place to minimize domestic industry impacts from dairy imports, is not a major dairy importing nation from any country. However, there have been US exports of milk ingredients such as whey and casein and consumer products like fluid milk and cream to the country over time.

The global recession of 2008–2009 provided a first test of the US dairy industry's resolve to remain engaged in commercial exporting of milk and dairy products. Export volume fell from 2.52 billion pounds (total solids) to 2.03 billion but rebounded in 2010 to 2.98 billion. The annual value of dairy exports fell from about $3.8 billion in 2008 to $2.2 billion in 2009 (a 42% decline) then rebounded to almost $3.7 billion in 2010, essentially fully recovering the previous loss. The dairy export volumes and values have continued to increase since, although they did slow in the latter half of 2014.

The continued US participation in bi-and multi-lateral trade agreements has also been a basis for interest in dairy export opportunities. The United States has finalized, or is currently in negotiations of, sixteen free trade or trade promotion agreements that include twenty individual countries in all parts of the world (Office of the United States Trade Representative, https://ustr.gov/). Only three (3) of these agreements were concluded prior to 2000, with Israel (1985), Canada (1988), and Mexico under NAFTA (1994). The Korea–US Free Trade Agreement (KORUS) is a recent example of how these efforts have had important impacts on the US dairy industry. By adjusting tariffs and other restrictions under KORUS, the value of US dairy product exports to Korea grew to $417 million. Fresh cheese exports alone accounted for $199 million— up 575% from the pre-KORUS base level ($30 million).

Export data for selected dairy products in Table 2 also illustrate the growth of the United States as a major dairy exporting nation. US exports for most of the products declined from 2008 to 2009, the end of the Great Recession. Butter exports had spiked in 2008 so the fall was large (85%) and the smallest decline was about 9% for the other-than-American cheese category. The recovery of dairy exports seen in 2010, by 259% in butter, 116% in American cheese, 82% in nonfat dry milk, 46% in other than American cheese, and 30% in whey products were indicative the US industry's continued interest in exporting.

Table 2. Selected dairy product exports, in million pounds, US 2000–2014 [2]

Year	Milk in all products [1]	Butter	American cheese	Other cheese	Nonfat dry milk [2]	Whey products
2000	1,876	1.4	18.1	76.1	43.9	414.8
2001	2,571	3.3	18.3	92.1	40.9	376.2
2002	2,283	3.0	24.4	92.4	1.0	397.3
2003	2,113	0.3	23.3	85.5	5.0	363.9
2004	3,137	13.0	30.8	98.1	262.1	444.0
2005	2,791	9.7	33.0	94.4	486.6	593.2
2006	3,080	18.5	32.2	124.4	631.8	741.7
2007	5,433	72.6	61.9	157.6	568.6	936.6
2008	8,782	175.4	89.0	200.2	862.2	772.6
2009	4,329	26.1	53.3	182.7	464.3	790.3
2010	8,452	93.6	115.2	266.6	845.8	1023.2
2011	9,389	115.1	160.9	335.3	959.2	1020.2
2012	8,810	95.5	163.2	410.0	980.1	1077.2
2013	12,353	178.3	200.0	497.2	1223.1	1149.5
2014 [3]	12,469	130.2	222.1	590.8	1203.6	1148.9

Note. [1] Milk equivalent, milkfat basis [2] For human consumption, after 2004 production includes Skim Milk Powder [3]Preliminary

Sources. USDA-FAS and UDA-ERS calculations.

In addition to identifying the products that are exported, it is also important to identify major export destinations when assessing the current US trade strategy. The top five (5) export destinations in 2000 and in 2014 for dairy product categories as defined by USDA's Foreign Agricultural Service (FAS 2016) are shown in Table 3.

Table 3. Top five US dairy export markets for dairy products, 2014 and 2000

2014					
Butter & Milkfat	Saudi Arabia	Iran	Morocco	Mexico	Egypt
Casein	Mexico	Canada	China	Germany	Brazil
Cheese & Curd	Mexico	South Korea	Japan	Australia	Canada
Condensed & Evaporated Milk	Mexico	China	Vietnam	South Korea	Malaysia
Dry Whole Milk & Cream	Vietnam	Mexico	China	Algeria	Colombia
Fluid Milk & Cream	Canada	Mexico	Taiwan	China	Hong Kong
Ice Cream	Mexico	Saudi Arabia	United Arab Emirates	Canada	Australia
Non-Fat Dry Milk	Mexico	Philippines	Indonesia	China	Vietnam
Other Dairy Products	Canada	China	Mexico	New Zealand	Japan
Whey	China	Mexico	Canada	Japan	Philippines
Yogurt & Other Fermented Products	Mexico	Philippines	Australia	Trinidad & Tobago	Canada
2000					
Butter and Milkfat	Mexico	Canada	Dominican Republic	Nigeria	Israel
Casein	Argentina	Canada	Brazil	Mexico	Chile
Cheese and Curd	Canada	Mexico	Japan	South Korea	Venezuela
Condensed and Evaporated Milk	Mexico	Venezuela	Australia	Canada	Argentina
Dry Whole Milk and Cream	Russia	Algeria	Yemen	Haiti	Tajikistan
Fluid Milk and Cream	Mexico	Hong Kong	Taiwan	Palau	Malaysia
Ice Cream	Japan	Mexico	United Kingdom	Canada	Hong Kong
Non-Fat Dry Milk	Mexico	Russia	Philippines	Dominican Republic	Indonesia
Other Dairy Products	Canada	Taiwan	Japan	Philippines	Mexico
Whey	Canada	Mexico	Japan	Philippines	China
Yogurt & Other Fermented Products	Mexico	Canada	Denmark	Australia	United Kingdom

Source. USDA–FAS

The previously mentioned importance of Mexico and Canada as destinations for US dairy products is seen in the table. Mexico appears as an export market for all eleven product categories in both 2014 and 2000 with one exception (Dry Whole Milk and Cream in 2000). Canada is also a market for several product categories in both years. Focusing on markets other than Mexico and Canada, we see that in today's (2014) global markets, US dairy export interests have shifted toward not only China, but also to other countries in Asia and the Pacific region There has also been recent interest by countries in North Africa and the Middle-east importing US dairy products.

US Domestic and International Dairy Market Linkages

The US dairy market is large but mature. Mature markets often exhibit only relatively slow growth in population and, as the characteristics and dynamics of that population change, supply and demand relationships among dairy products change as well. The continuing steady growth of US milk production suggests that additional dairy product markets, including international ones, need to be established and nurtured. Otherwise, milk price and industry supply chain issues may appear in the US. Export sales help support US producer milk prices when the domestic economy itself may be sluggish and affect dairy product stocks and their potential impacts on domestic prices.

In general, export markets carry benefits and risks beyond US control. Macroeconomic factors that affect currency exchange rates are a fundamental issue to consider. US dairy exporters need to be cognizant of the strength or weakness of the US dollar relative to a competing exporting country's currency and to the currency in a potential export market. A weaker dollar is advantageous for exporting US produced products. For an extended period, from 2003 to 2012, the US dollar was, in general, steadily depreciating relative to other currencies. That depreciation provided support for increased US agricultural exports, including milk and dairy products (Cooke et al. 2016). When the dollar is strong, the US becomes more attractive to exporters so US milk and dairy product imports may increase. While clearly important, exchange rate conditions are not the only important factor affecting trade.

The ban on some imports of dairy products imposed by Russia that has been extended for some time illustrates such a risk. Along with China, Russia has become a key market for traded agricultural products as its food economy has been buffeted by several factors (Liefert and Liefert 2015). Since US dairy product exports to Russia were not large, the direct effects of the ban are small. However, significant indirect effects may be seen as other dairy product exporters banned from sales to Russia, in this case mainly EU countries, redirect exports into markets where they will more directly compete with existing US imports. What had been essentially a seller's market is transformed into a buyer's market as alternative product supplies appear. Unique events such as import bans are not the only sources of risk in export markets.

There is seasonality that affects supplies since the major exporters of dairy products are located in both the Northern and Southern hemispheres. Unexpected or more severe than usual weather conditions can also significantly alter milk production, as can other natural disasters. Transportation issues involving ports are also potentially disruptive for dairy trade as the recent actions at the Ports of Los Angeles and Long Beach highlighted.

Even though the World Trade Organization (WTO) has made agricultural trade more transparent by establishing tariff-based regulations, heated agricultural trade debates have not been eliminated. The political power of agricultural organizations to influence trade policy is still strong in many countries. Sanitary and phyto-sanitary regulations are often cast in terms of food quality and safety issues but as non-tariff based regulations they can hide elements of economic protectionism.

The release of the Bain Report (Innovation Center for U.S. Dairy 2009) may have had a role in determining the US industry response to commercial exporting opportunities since its publication. Four potential US dairy trade strategies were outlined in the report: "Fortress USA", Status Quo, Consistent Exporter and Global Dairy Player. The Innovation Center Board of Directors recommended following the Consistent Exporter strategy that included six (6) components:

1. commitment to global opportunities,
2. broad efforts to improve commercial focus and align product portfolios,

3. collective efforts to reform US dairy policy/programs,
4. efforts to improve forward contracts, futures markets,
5. maintaining a strong domestic market as the basis for trade, and
6. joint efforts in the industry to build insight/capabilities.

The question is, how is this strategy working for the US dairy industry? Our answer is, we believe "Quite well." There have been notable results achieved for all of the elements but here we consider only elements 1, 2 and 6 since they are those where greater changes in industry perspectives would likely have been required.

International dairy market participants must balance changing demand conditions in local markets with competing for reliable supplies of milk and dairy products from international market sources. The US dairy industry is an attractive target for foreign investment of various kinds (Blayney et al. 2006). Joint ventures and agreements with major international trading organizations such as Fonterra (New Zealand) and Glanbia (Ireland) have marked US dairy industry efforts to build the insights and capabilities to become more engaged in exporting. Such agreements linked the large, relatively stable supplies of US dairy products with international trading expertise. The US "side" of several of these agreements has been Dairy Farmers of America (DFA), the largest farmer-owned dairy cooperative in the country.

Proprietary US dairy companies have also made major commitments to this effort. Both Hilmar Cheese Co. and Leprino Foods made major investments in building dairy product capacity after 2000. Hilmar and Leprino have extensive cheese manufacturing capacity which also brings with it large quantities of whey that can be further processed. A look at the websites of these companies shows how they have developed an extensive range of whey and dry products that can meet customers' specifications.

Dairigold, another US farmer-owned dairy cooperative, added dry whole milk production capabilities to its operations during renovation of its manufacturing facilities in 2013. The action illustrates a commitment to bring back production of a product that had shown demand growth in international markets. DFA followed suit by constructing a state of the art dry milk plant in Nevada to supply Chinese dry whole milk demands and has also announced plans for a joint venture with a Chinese dairy cooperative for a plant in western Kansas. It is clear that US dairy businesses have been making broad efforts to improve commercial focus and align product portfolios to meet the demands of international customers. These efforts also strengthen the US domestic dairy product markets as changing consumer tastes and preferences appear.

Can We Find Empirical Evidence for Claims?

The narrative of how the US dairy industry has changed from a sporadic to a consistent supplier to international markets is well-documented. But if the structure of total domestic US demand for milk and dairy products has been changed due to more involvement in export markets, does industry data offer any empirical clues to support that claim?

Major empirical modeling is not the purpose here. Instead, some basic exploratory analysis of selected aggregate data is provided. Given the apparent changing role of the US in commercial exports of dairy products, a method of assessing various indicators of changing trade polices (Diakosavvas 2001) is used for the analysis. The four indicators suggested by Diakosavvas were calculated using the aggregate milk equivalent, fat basis data previously shown in Table 1.

Each indicator is defined as a ratio. Trade Openness is the ratio of imports plus exports to production, Import Penetration is the ratio of imports to consumption, Export Performance is the ratio of exports to production, and Net Trade Performance is the ratio of the difference between exports and import to the sum of the two. The trade indicators are examined in a before and after framework as in the study by Jones and Blayney (2004) that focused on three particular dairy products and eight countries.

The before and after framework lends itself to nonparametric statistical analysis. As a general statement, nonparametric tests are not as powerful as parametric tests that depend on distributional assumptions. The before (Pre-WTO) period is 1995 to 2000 and the after (Post-WTO) period is 2001 to 2014. Such a framework permits analysis (tests) of means, medians, and variances across subsamples of a single data series. The tests are based on the assumption that the subsamples are independent. Table 4 shows the average values and the difference between them of aggregate production, consumption, imports, exports, and the calculated Trade Policy Indexes.

Table 4. Mean and median summary of data and trade indicators for pre- and post-WTO time frames

	Pre-WTO	**Post-WTO**		**Pre-WTO**	**Post-WTO**	
Data (Million pounds)	Average		Difference	Median		Difference
Production	19,642.4	23,152.4	3,510.0	19,384.8	23,338.0	3,953.2
Commercial Disappearance	18,908.7	21,253.5	2,344.8	18,780.1	21,496.9	2,716.8
Exports	638.4	2,275.4	1,637.0	614.9	2,148.0	1,533.1
Imports	554.3	742.7	188.4	543.3	765.2	221.9
Indexes						
Trade Openness	0.060	0.128	0.068	0.059	0.132	0.072
Import Penetration	0.029	0.035	0.006	0.029	0.038	0.009
Export Performance	0.032	0.096	0.063	0.031	0.094	0.063
Net Trade Performance	0.079	0.433	0.354	0.101	0.467	0.366

The nonparametric test results for the four trade indexes are reported in Table 5. The null hypothesis being tested for each index is the means of the two subsamples and the medians of the two subsamples are equal against the alternative in each case that they are not equal. As a practical matter, analysts may choose any single test to report but in this case all of the tests available in the chosen statistical package (E-Views 8) are shown.

Table 5. Tests for equality of the means and medians of dairy trade indicators

	Trade Openness		**Import Penetration**		**Export Performance**		**Net Trade Performance**	
Means								
Method	Value	Probability	Value	Probability	Value	Probability	Value	Probability
t-test	4.7774	0.0002	1.9601	0.0657	3.8991	0.0011	3.2839	0.0041
Satterthwaite-Welch	6.9964	0.0000	1.8834	0.0932	6.0002	0.0000	4.5085	0.0003
Anova F-test	22.8237	0.0002	3.8420	0.0657	15.2029	0.0011	10.7843	0.0041
Welch F-test	48.9498	0.0000	3.5472	0.0932	36.0022	0.0000	20.3261	0.0003
Medians								
Method	Value	Probability	Value	Probability	Value	Probability	Value	Probability
Wilcoxon/Mann-Whitney	3.4229	0.0006	1.9382	0.0526	3.4229	0.0006	2.5156	0.0119
Wilcoxon/Mann-Whitney (tie-adjusted)	3.4229	0.0006	1.9382	0.0526	3.4229	0.0006	2.5156	0.0119
Median Chi-square	8.5714	0.0034	0.9524	0.3291	8.5714	0.0034	8.5714	0.0034
Adjustd Median Chi-sq.	5.9524	0.0147	0.2381	0.6256	5.9524	0.0147	5.9524	0.0147
Kruskall-Wallis	12.0000	0.0005	3.9184	0.0478	12.0000	0.0005	6.5374	0.0106
Kruskall-Wallis (tie-adjusted)	12.0000	0.0005	3.9184	0.0478	12.0000	0.0005	6.5374	0.0106
van der Waerden	11.5211	0.0007	4.4780	0.0343	11.5211	0.0007	6.3530	0.0117

Note. Estimates calculated using E-views 8 statistical software.

The probabilities indicate relatively strong rejections (5% or less) of the null hypotheses in most cases except for the Import Penetration indicator. The tests tend to support the notion that growing commercial export opportunities for the US after 2000 have changed the dairy export situation of the United States.

The nonparametric analysis does offer some interesting glimpses at the changing export position of the United States in what has been called the Post-WTO period. However, that analysis is based on a milk equivalent basis. It has been suggested that many interested readers might better follow discussions cast in terms of specific products. There is no specific statistical testing of the product data that follows.

It has been suggested that exchange rate for various dairy products are important for exporters to be aware of. The following table, Table 6 is a reprise of the previous Table 2. Included are annual real trade-weighted values for the US dollar (defined as an index) for the 2000–2014 period.

Table 6. Selected dairy product exports and trade-weighted US dollar exchange rate, 2000–2014 [2]

Year	Milk in all products [1]	Butter	American cheese	Other cheese	Nonfat dry milk [2]	Whey products	Real trade-weighted dollar exchange rate index [3]
	million pounds						
2000	1,876.0	1.4	18.1	76.1	43.9	414.8	116
2001	2,571.0	3.3	18.3	92.1	40.9	376.2	123
2002	2,283.0	3.0	24.4	92.4	1.0	397.3	124
2003	2,113.0	0.3	23.3	85.5	5.0	363.9	121
2004	3,137.0	13.0	30.8	98.1	262.1	444.0	117
2005	2,791.0	9.7	33.0	94.4	486.6	593.2	114
2006	3,080.0	18.5	32.2	124.4	631.8	741.7	112
2007	5,433.0	72.6	61.9	157.6	568.6	936.6	108
2008	8,782.0	175.4	89.0	200.2	862.2	772.6	103
2009	4,329.0	26.1	53.3	182.7	464.3	790.3	106
2010	8,452.0	93.6	115.2	266.6	845.8	1,023.2	100
2011	9,389.0	115.1	160.9	335.3	959.2	1,020.2	96
2012	8,810.0	95.5	163.2	410.0	980.1	1,077.2	97
2013	12,353.0	178.3	200.0	497.2	1,223.1	1,149.5	98
2014 [4]	12,469.0	130.2	222.1	590.8	1,203.6	1,148.9	100

Note. [1] Milk equivalent, milkfat basis
[2] For human consumption, includes skim milk powder after 2004
[3] 2009 dollars, base year 2010 = 100
[4] Preliminary
Sources. USDA-FAS and USDA-ERS

Analyzing the correlation between each product's quantity of exports and the trade-weighted dollar index shows the relationship that is expected. The estimated correlation coefficients range from a high of -0.95 for whey products to a low of -0.81 for the other than American cheese style products. The negative correlation implies that as the US dollar weakens (depreciates) there is a positive effect on exports. Likewise the appreciation of the US dollar results in a negative trade effect. The trade-weighted index in this case is for all agricultural products, not just dairy products but the results are as expected. A more sophisticated empirical model would be able to cast the results in terms of elasticity measures. Also, a dairy-trade weighted index could be employed to gain further insights.

A Pre- and Post WTO classification has also been implemented to examine alternative statistical measures associated with the quantities and values of US dairy products. The two following tables, Table 7 and Table 8 contain summary data on specific product exports.

From 1995 to 2000, some dairy exports such as whey grew 60% in value, compared to a 45% increase in cheese and curds, and 19% increase in non-fat dry milk. Whey exports were the US largest dairy market followed by nonfat dry milk. On average, the US exported 10,941 metric ton of whey over six years at an average value of $10.4 million. While some dairy products grew at a very moderate rate, other dairy products like dry whole milk, butter and milk-fat experienced declines in exports over the observed period. During this period, dry whole milk declined 61% in volume and 63% in value. Butter and milk-fat were hardest hit dropping 79% in volume and 89% in value from 1995 through 2000.

After the URAA was fully implemented, a new trade regime was established which helped bring forth waves of US dairy trade flows. Over the past fourteen years, US dairy exports have increased more than seven-fold. Whey continues to be the US largest dairy market averaging over 29,253 metric ton and $40.62 million in export value (Table 8). In March of 2014, whey exports totaled 53,224 metric tons compared with only 19,081 metric tons before 2001. March 2014 is the largest US whey trade recorded.

Table 7. US Dairy Exports, Pre-Implementation of the Uruguay Round (UR) Agreement (1995–2000)

Variable	Mean	SD	Max	Min
Quantity metric tons				
Whey	10,940.94	2,726.47	19,081.60	5,848.90
Nonfat dry milk	6,088.82	4,332.01	18,554.00	245.80
Dry whole milk	3,102.98	2,438.74	9,296.80	450.80
Butter and milk fat	1,538.95	2,461.44	17,073.40	57.80
Cheese and curd	3,089.14	618.37	4,795.40	1,809.10
Value ($1000)				
Whey	10,413.08	1,973.01	17,144.00	6,005.00
Nonfat dry milk	9,856.54	6,438.14	27,826.00	291.00
Dry whole milk	4,563.83	4,115.70	14,316.00	465.00
Butter & milk fat	2,226.25	2,918.33	1,478.00	85.00
Cheese & Curd	9,808.88	1,890.24	14,311.40	5,645.00

Source. USDA-FAS dairy export data for selected years. Descriptive statistics were calculated by the authors.

The United States is the second largest, in terms of volume, dairy market in nonfat dry milk. From 2001 through 2014, the US average monthly export of nonfat dry milk totaled 25,834 metric tons at a value of $76.16 million (Table 8). A record setting shipment (60,710 metric tons) of US nonfat dry milk was achieved in June 2014. The growth in nonfat dry milk exports is tremendous when June 2014 volume is compared to February 2002 volume of 1,515 metric tons.

Of the five dairy products, butter and milk-fat experienced the greatest increase in volume (almost eighteen-fold) and value (over fifty-fold), followed by cheese and curd, nonfat dry milk, whey, and dry whole milk. Dry whole milk has grown the least of the dairy products due to society increasing demand for healthier foods.

Table 8. US Dairy Exports, Post-Implementation of the Uruguay Round (UR) Agreement (2001–2014).

Variable	Mean	SD	Max	Min
Quantity metric tons				
Whey	29,253.17	11,342.76	53,224.60	10,927.40
Nonfat dry milk	25,834.59	14,083.98	60,709.80	1,515.40
Dry whole milk	2,729.09	2,081.16	16,194.40	312.60
Butter and milk fat	3,218.43	3,095.60	12,413.70	129.80
Cheese and curd	12,088.99	8,809.28	36,163.30	3,437.50
Value ($1000)				
Whey	40,617.05	26,041.87	104,646.00	7,829.00
Nonfat dry milk	76,159.12	57,623.39	231,589.00	2,566.00
Dry whole milk	5,947.15	4,890.50	21,151.00	426.00
Butter & milk fat	10,802.31	11,701.80	49,302.00	242.00
Cheese & Curd	49,587.51	41,134.06	162,933.40	10,334.00

Source. USDA-FAS dairy export data for selected years. Descriptive statistics were calculated by the authors.

Conclusions

The US dairy industry has grasped the opportunity to increase its footprint in international export markets during the last decade by following the strategy to be a consistent exporter. Industry-wide and individual dairy business efforts required to maintain the strategy have been made and appear to be expanding to meet future trade opportunities as they arise. There have been some commentaries that suggest the United States can respond quickly to export opportunities but may not have a long-term willingness to maintain efforts or even expand them to keep them. The reported investments by US companies since about 2005 to meet the recommendation to remain a consistent exporter of high-quality and desired products suggest otherwise.

The preliminary analyses provide insights for more detailed and complete analysis of the assertion that the growth in US commercial exports has altered the domestic dairy demand in the country. As one reviewer mentioned to the authors, such an analysis would likely be more useful for specific product rather than aggregate measures of milk. The export data indicates that the US has directed major efforts toward exporting dry products such as nonfat dry milk, whole milk powder and dry whey products. These are the products the US has focused on manufacturing and exporting for some time. However, opportunities may exist for more exports of the other traditional products like cheese and butter as well as new export markets emerge.

The decline seen in US dairy exports in 2014 has continued into 2015 and several concerns have been raised in that regard. The changing dairy product import demands of China and Russia is one factor but there has also been a surge in world-wide milk production. These supplies and demands must be balanced. It has been noted that the general decline observed for the aggregate measures of milk and dairy products do not translate into consistent declines among individual products. There are many unknowns in both domestic and export markets for dairy, and indeed for all, food products. As issues such as climate change, the use of agricultural technologies, including biotechnology, and food safety, security, and availability are debated and, hopefully resolved, dairy and other agricultural trade relationships will face adjustments.

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Appendix

Table A1. Annual commercial disappearance, milk in all products, milk-equivalent milk-fat basis, 1995–current (millions of pounds)

Table A1. Annual commercial disappearance, milk in all products, milk-equivalent milk-fat basis, 1995–current (Millions of pounds)

Year	Beginning commercial stocks [A]	Farm Milk Supply: Production	Farm Milk Supply: Farm use	Farm Milk Supply: Marketing [B]	Imports [C]	Total supply [A+B+C]	USDA net removals [1]	Commercial Use: Domestic commercial disappearance	Commercial Use: Commercial exports [2]	Commercial Use: Total commercial disappearance	Ending commercial stocks [3]
1995	4,164	155,292	1,556	153,736	2,293	160,193	2,096	151,005	3,059	154,064	4,033
1996	4,033	154,006	1,476	152,530	2,651	159,214	87	151,782	2,682	154,464	4,663
1997	4,663	156,091	1,394	154,697	2,918	162,278	1,092	154,531	1,833	156,364	4,822
1998	4,822	157,262	1,377	155,885	4,868	165,575	367	158,180	1,831	160,011	5,197
1999	5,197	162,589	1,326	161,263	4,948	171,409	346	163,463	1,532	164,996	6,067
2000	6,067	167,393	1,307	166,086	4,502	176,655	846	167,149	1,876	169,025	6,784
2001	6,784	165,332	1,209	164,123	6,491	177,398	145	167,707	2,571	170,278	6,976
2002	6,976	170,063	1,119	168,944	6,151	182,070	327	169,662	2,283	171,945	9,799
2003	9,799	170,348	1,127	169,221	6,172	185,192	1,161	173,650	2,113	175,763	8,268
2004	8,268	170,832	1,115	169,717	7,028	185,013	-72	174,860	3,137	177,997	7,088
2005	7,088	176,931	1,095	175,836	7,425	190,349	-40	179,669	2,791	182,460	7,929
2006	7,929	181,782	1,081	180,701	7,489	196,119	14	183,578	3,080	186,658	9,447
2007	9,447	185,654	1,089	184,565	7,180	201,191	0	185,456	5,433	190,889	10,302
2008	10,302	189,978	1,068	188,910	5,264	204,476	24	185,679	8,782	194,461	9,991
2009	9,991	189,202	1,013	188,189	5,562	203,742	917	187,258	4,329	191,586	11,238
2010	11,238	192,877	980	191,897	4,055	207,190	262	187,661	8,452	196,113	10,816
2011	10,816	196,255	965	195,290	3,510	209,616	0	189,361	9,351	198,712	10,904
2012	10,904	200,642	956	199,686	4,078	214,668	0	193,663	8,810	202,473	12,195
2013	12,195	201,231	977	200,254	3,722	216,171	0	192,639	12,359	204,998	11,173
2014	11,173	206,054	964	205,090	4,315	220,579	0	196,911	12,444	209,355	11,224
2015	11,224	208,633	969	207,664	5,685	224,572	0	202,498	8,761	211,259	13,313

Notes. [1] The Dairy Products Price Support Program and the Dairy Export Incentive Program were repealed by the Agricultural Act of 2014. USDA net removals = price support purchases + Dairy Export Incentive Program exports - unrestricted sales of stocks held by USDA Commodity Credit Corporation (CCC). USDA conducted a barter program in 2009 and 2010; Government stocks of nonfat dry milk were exchanged for products containing substantial dairy content. Although barters are different from USDA net removals, the net transfer of milk-equivalent milk fat from the commercial market to the Government was added to USDA net removals in this table.

[2] Commercial exports = total exports - Dairy Export Incentive Exports - Government donations to foreign countries.

[3] Includes commercial stocks of butter, American cheese, other-than-American cheese, nonfat dry milk, and dry whole milk.

Sources. USDA National Agricultural Statistics Service, USDA Farm Service Agency, USDA Foreign Agriculture Service, U.S. Department of Commerce Bureau of the Census, USDA Economic Research Service calculations.

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United States and European Union Dairy Farms: Where Is the Competitive Edge?

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The United States (US) and European Union (EU) dairy industries are undergoing rapid structural change as farms become fewer and larger, milk productivity per cow increases, and agricultural policies evolve. This paper examines productivity measures of dairy farms in all dairy production regions of the US and seven member states of the EU. We generally find that larger, more intensively-managed dairy farms experience greater net return on assets and are more scale efficient than smaller, more extensive dairy farms. Efficient farms are found in all farm size and system categories, with many of the smaller farms experiencing relatively high technical efficiency. Overall, we find significant economic forces at work towards more efficient and productive dairy production in both the EU and the United States. With potential efficiency gains that can be made, various EU dairy production regions may significantly strengthen their export positions following the milk quota seizure of 2015.

Keywords: dairy productivity; transformation function; scale efficiency; technical efficiency

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Introduction

The global dairy industry has exhibited significant structural change over the past few decades, including shifts in production location, growth in farm size, and change in farm production systems. These changes are evident in both the United States (US) and the European Union (EU), but the extent to which industry structure has evolved has differed by country. Evidence of structural change has been shown in country-specific analyses by MacDonald et al. (2007), Melhim et al. (2007), Nehring et al. (2009), and Gillespie et al. (2014) for the US and Perrot et al. (2007), Sauer (2010), McDonald et al. and Sauer and Latacz-Lohmann (2015) for the EU.

A new potential impetus for structural change in the EU is expected to be the 2015 elimination of the dairy quota, which should move dairy from the least efficient to the most efficient areas across borders. Furthermore, the current push in Common Agricultural Policy reform is to include payments to farmers to counter the effects of climate change and reduce greenhouse gas emissions, including from dairy animals. No similar payments have been included in US legislation. A potential impact of these changes taken together is that the EU can further enhance its current position as one of the world's top dairy exporters. There are likely, however, to be localized impacts for both the higher and lower-cost regions of Europe, with some regions gaining, and others losing relative dairy competitiveness. The promotion of organic farming has been another important element of national and supranational food policy throughout Europe and is also an important feature of US dairy policy (Breustedt et al. 2011). Thus, there are a number of important policy changes that have the potential to impact dairy industry structure.

Given the current fundamental changes in the EU dairy sector, the purpose of this paper is to provide analyses of the underlying dairy production structure in both the EU member countries as well as in the US, considering policy developments over the last decade. We provide a quantitative comparison of different production systems in the EU and US using a multi-output transformation function approach. Using a common analytical framework allows for insights on the competitiveness of the two regions by production system. Furthermore, future developments given the described policy changes can be discussed. Conclusions can be drawn regarding the EU's low-cost dairy producers' potential to remain and become net dairy product exporters (Bojnec and Ferto 2014), as well as the US's potential to retain its global market share given the changes in the dairy market.

Background

The US and the EU are major players in world trade of dairy products. Of the top five major exporters of dairy products (Argentina, Australia, the EU, New Zealand, and the US), the EU and the US accounted for about 85% of total milk production in 2014 (USDA-FAS 2015). Furthermore, they are the top two producers of milk in the world. In 2014, the EU produced 146.5 million metric tons of milk and the US produced 93.5 million metric tons, with the third-highest production of milk coming from India, at 60.5 million metric tons (USDA-FAS 2015). There are other major players in dairy trade, most notably New Zealand, which ranked first in the export of whole milk powder and butter, second in nonfat dry milk, and third in cheese in 2014 (USDA-FAS 2015). However, New Zealand produced 21.9 million metric tons of milk in 2014, so it was significantly smaller (ranked seventh) than the EU and the US in total milk production.

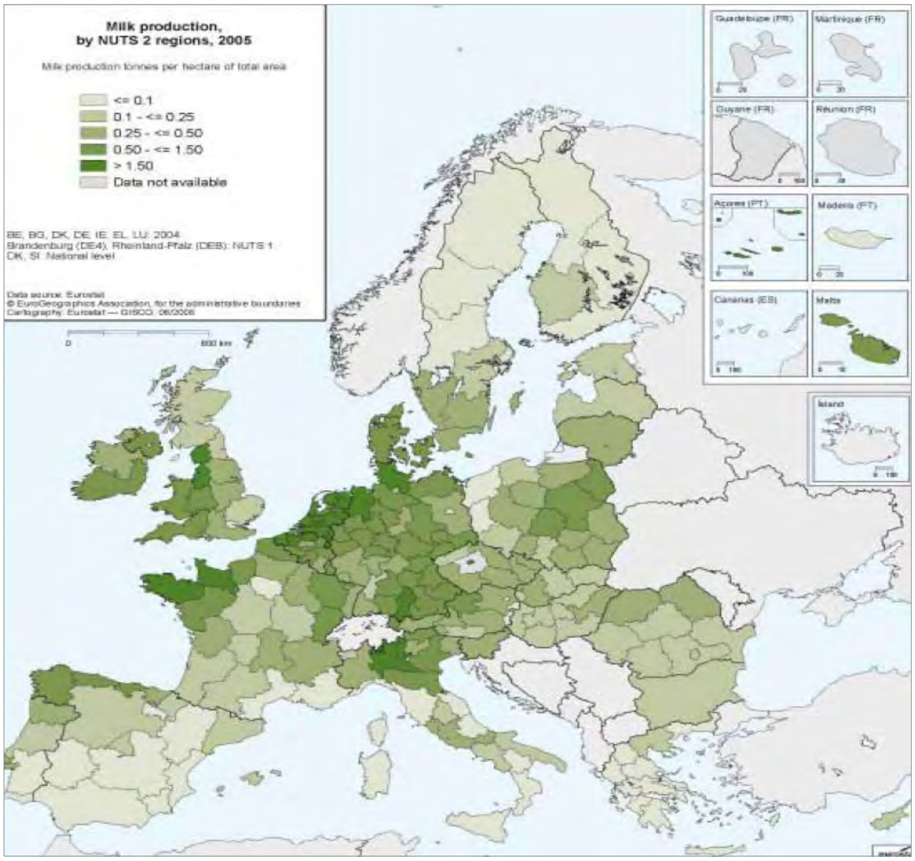

Figure 1. Major dairy producing districts by EU country
Source. Eurostat 2009.

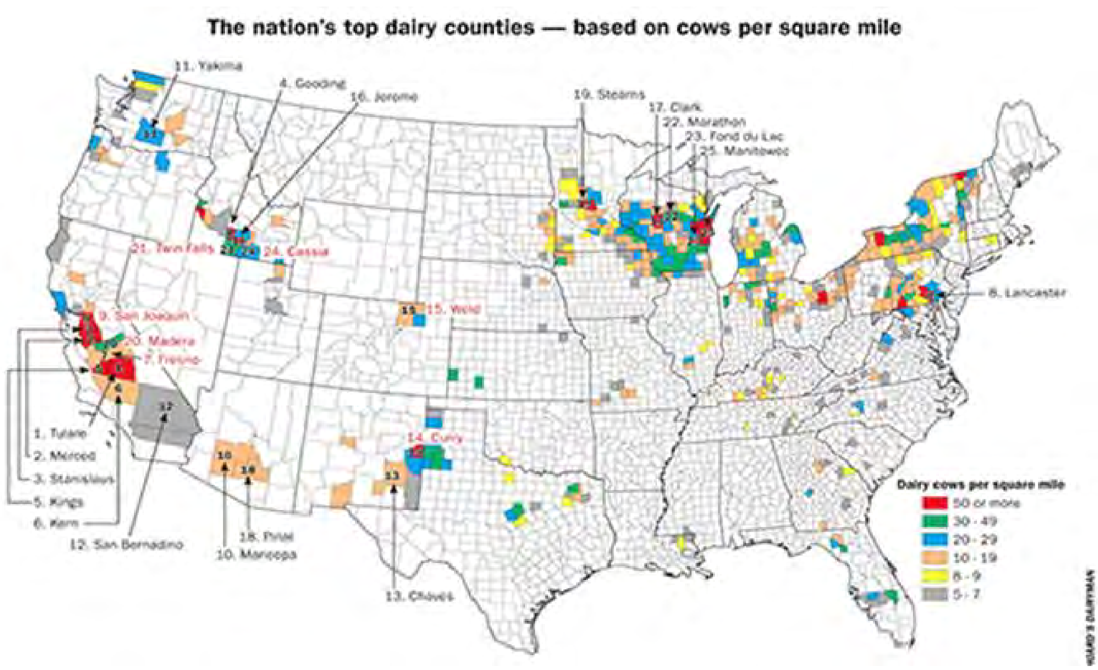

Figure 2. Top dairy counties in the United States in 2012
Source. Hoards Dairyman Staff (2014).

According to MacDonald et al. (2007) the cost advantage of larger farm sizes in the United States allow those farms to be profitable on average, while most small farms are unable to earn enough to replace their capital. Historical survey evidence, including farm financial data, suggests further consolidation is inevitable if current trends continue. Though pasture-based operations generally yield lower milk per cow, their production costs are also lower. Previous work has shown that pasture-based operations tend to be competitive with conventional (no pasture with total mixed ration feeding) operations of similar size (Gillespie et al. 2009; Gillespie and Nehring 2014).

Though several different definitions have been used for pasture-based operations, Gillespie et al. (2009) and Gillespie and Nehring (2014) define these operations as having ≥50% of the forage requirement being met through pasture during the grazing season, and the definition is generally consistent with current organic dairy production rules that require ≥30% of dry matter to be from pasture during the grazing season (Gillespie et al. 2014). Gillespie and Nehring (2014) show that, for 2010, 38%, 37%, and 16% of US dairy farms were conventional, semi–pasture–based (1% – 49% of the forage requirement was met via pasture during the grazing season), and pasture-based, respectively, with the remaining 9% of the operations being organic.

In the EU, milk production takes place in all member states and represents 14% of the value of EU agricultural output. The share of milk in total agricultural production varies between member states, from 6% to 34% in 2006. The share tends to be higher in northern Europe and is below 10% in the Mediterranean countries (EC 2006). During the early 1980s, the EU experienced large production surpluses of milk and dairy products. To prevent further increases and to limit milk production, a country-specific milk quota scheme was introduced to control production. This effectively put a limit on the amount of milk EU dairy farmers produced each year.

Significant structural change and improvements in dairy herd productivity have occurred in several EU countries in recent years. United Kingdom (UK) dairy farms, for example, are developing within the context of agricultural policy which allows for geographical mobility of quotas, low consumer milk prices, and difficulties maintaining production volume. Farms are characterized by strong labor productivity and relatively low investment, enabling one of the highest mean agricultural household incomes among the regions of the EU. In Denmark, dairy farms are characterized by the highest average labor productivity in the EU (Perrot et al. 2007).

In contrast, the larger dairy sectors in the EU, Germany, France, and Italy—with combined farm numbers of nearly four times larger than that of the US—have experienced large reductions in total dairy numbers in recent years while average herd sizes have remained small and milk output has been relatively low (Table 1). In France, for example, low mobility of dairy quotas and high soil quality have led to the prevalence of more traditional, less specialized, dairy farms. Hence, these dairy farms produce less milk than in EU countries with more specialized dairy sectors, with large parts of their output consisting of cereals and beef (Perrot et al. 2007).

Use of a Transformation Function to Measure Dairy Productivity

The dairy farms included in our cross-country sample use multiple factors to produce milk, other livestock products, and crops. Hence, it is desirable to model these processes using a function that accounts for the production of multiple outputs with multiple inputs. Following Sauer and

Morrison-Paul (2013), we use a transformation function to represent the most output producible given the feasible production set. This function in general form can be written as 0=F(**Y,X,T**), where **Y** is a vector of outputs, **X** is a vector of inputs, and **T** is a vector of (external) shift variables, which reflects the maximum output producible from a given input vector and existing external conditions. By the implicit function theorem, if F(**Y,X,T**) is continuously differentiable and has non-zero first derivatives with respect to one of its arguments, it may be specified (in explicit form) with that argument on the left hand side of the equation.

Accordingly, we estimate the transformation function $Y_1 = G(\mathbf{Y_{-1}},\mathbf{X},\mathbf{T})$, where Y_1 is the primary output of dairy farms (milk) and $\mathbf{Y_{-1}}$ is the vector of other outputs, to represent the technological relationships for the dairy farms in our sample. Note that this specification does not reflect any endogeneity of output and input choices, but simply represents the technologically most Y_1 that can be produced given the levels of the other arguments of the transformation function. This is important because in the alternative input (output) distance function approaches, for example, one input (output) is required for normalization in order to impose linear homogeneity. This raises issues not only about what variable should be expressed as ratios with respect to the left-hand side variable, but also about econometric endogeneity because the right-hand side variables are expressed as ratios with respect to the left-hand side variable. See Mas-Colell et al. (1995), page 128–29 for a fuller discussion and a graphical presentation of the transformation function set and transformation frontier.

We estimate the transformation function $Y_{M,it} = F(\mathbf{Y}_{NM,it}, \mathbf{X}_{it}, T)$, where Y_M is milk production measured in real dollars or Euros for farm *i* in period *t* and $\mathbf{Y}_{NM}$ is non-milk production to include crop production, other non-milk livestock production, and off-farm income measured in real dollars or Euros. Vector **X** indicates inputs to include labor, cows, energy, fodder, capital, livestock-specific expenses, chemicals, machinery, seed, and land (measured in real dollars or Euros[1]). A limitation is that we do not have quality adjustment measures for land, but only measures for land value. For the US, due to some differences in categorization of inputs, the inputs were labor, fertilizer, pesticides, fuel, miscellaneous, land, crop-specific expenses, and livestock-specific expenses. Variable T represents year.

A number of flexible functional forms may be used to represent production technology, such as the translog, quadratic, and generalized linear. As suggested by Diewert (1973), the generalized linear functional form is used for our study to avoid variable calculations that would lead to zero netput values (which would occur with functional forms that include logarithms). As shown by Sauer and Morrison-Paul (2013), for farm *i* in period *t*, the functional form for our study is:

[1]The real input costs used for the U.S. analysis are not cost of production estimates developed by the U.S. Department of Agriculture, Economic Research Service (ERS). Rather they are variables such as cash wages or feed purchased as reported in ARMS that are deflated by prices paid indexes available in the U.S. Department of Agriculture's *Agricultural Statistics*. Similarly, dairy revenues and other outputs are not ERS estimates but variables appropriately deflated using prices paid indexes from *Agricultural Statistics*. The US dairy data are constructed using a whole farm approach, so all outputs, including off-farm income, are considered so that labor used in the dairy enterprise or in another enterprise such as a cow/calf operation are added together. Similarly, other inputs may be used in more than the dairy enterprise. This approach contrasts with a dairy enterprise approach used by, for example, Mosheim and Lovell (2009) where only the outputs and inputs produced or used in the dairy enterprise are considered. Further, we use the hired wage rate as the opportunity cost for labor. ERS publications used a more complicated algorithm based on an index of labor costs and the price of milk (www.ers/data/gov 2011).

1) $Y_{M,it} = F(Y_{NM,it}, X_{it}, T) = a_0 + 2a_{0NM}Y_{NM}^{0.5} + \sum 2a_{0k}X_k^{0.5} + a_{NMNM}Y_{NM} + a_{kk}X_k + \sum a_{kl}X_k^{0.5}X_l^{0.5} + \sum a_{kNM}X_k^{0.5}Y_{NM}^{0.5} + b_T T + b_{TT}TT + \sum b_{KT}X_k^{0.5}T + b_{NMT}^{0.5}T.$

To represent and evaluate the production structure, we compute the first-order elasticities of the transformation function. The first-order elasticities in terms of the milk output Y_M represent the (proportional) shape of the production possibilities frontier (given inputs) for output Y_{NM} and the shape of the production function (given other inputs and Y_{NM}) for input X_K – or output trade-offs and input contributions to milk output, respectively. That is, the estimated output elasticity with respect to the non-milk output, $\varepsilon_{M,NM} = \partial \ln Y_M/\partial \ln Y_{NM} = \partial \ln Y_M/\partial \ln Y_{NM} * (Y_{NM}/Y_M)$, is expected to be negative as it reflects the slope of the production possibilities frontier, with its magnitude capturing the marginal trade-off between milk and non-milk outputs. The estimated output elasticity with respect to input k, $\varepsilon_{M,K} = \partial \ln Y_M/\partial \ln X_K = \partial Y_M/\partial X_K * (X_K/Y_M)$, is expected to be positive, with its magnitude representing the (proportional) marginal productivity of X_K.

Returns to scale (RTS) may be computed as a combination of the Y_M elasticities with respect to the non-milk output and inputs. For example, for a production function, RTS is defined as the sum of the input elasticities to, in a sense, reflect the distance between isoquants. Similarly for a transformation function, such a measure must control for the other output(s). Formally, RTS is defined for the transformation function as $\varepsilon_{M,X} = \varepsilon_K \ \varepsilon_{M,K} \ /(1-\varepsilon_{M,NM})$. Technical efficiency is defined as the ratio of the observed output to the frontier output that could be produced by a fully efficient firm. Thus, technical efficiency of a farmer is between zero and one and is inversely related to the inefficiency effect. The TE (technical efficiency) "scores" are estimated as TE = $\exp(-u_i)$. It is assumed that the inefficiency effects are independently distributed and u_i arise by truncation (at zero) of the exponential distribution with mean m_i, and variance σ^2.

Data and Methods

For the EU, we use Eurostat data sets for 1999 through 2007 from Denmark (3,744 observations), France (12,180), Germany (15,524), Italy (13,272), Spain (11,315), and the UK (5,970) to represent dairy production (Eurostat 2014). We also use available FADN data for the years covered in the analysis. Organic operations in these dairy surveys are self-identified. The extent of pasture use is determined on the basis of stocking density estimates provided by the survey respondents. These are determined on the basis of number of cows divided by pasture in hectares, with the most intensive operations having ≤0.5 hectares per cow and the most extensive having >1.5 hectares per cow. The EU countries we examine account for about 70% of EU milk production, with Germany accounting for 21%, France 18%, UK 10%, Italy 8%, Spain 4%, and Denmark 3%.

For the US, data on dairy farms is used in the following regions: Appalachia, Corn Belt, Lake States, Mountain West, Northeast, Northern Plains, Southeast, Southern Plains, and Pacific. The data are from USDA's Agricultural Resource Management Survey (ARMS) for 1999-2007, and include 8,233 dairy farms. The states included are Arizona, California, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, New York, New Mexico, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, and Wisconsin and represent approximately 85% of the US milk production. Our US sample includes the "traditional" US dairy region (the Corn Belt, Lake States, and Northeast), farms that are arguably the most similar in technology usage to those in the EU, with a mix of farms including some that use total mixed rations and others that rely either to limited or extensive degrees on pasture. We also include the bulk of dairy operations in the western, southwestern, and southern US, many of which tend to be larger-scale. We encountered estimation challenges with the transformation function when including California, Oregon, and Washington due to the heterogeneity of dairy operations there, which we solved by including the major producing counties only in these states—accounting for about 70% of production in each state. Thus, our results represent the major dairy production regions for both the US and the EU.

The EU and US micro data sets used are harmonized with outputs and inputs similarly defined, so that cost advantages by country and technology can be identified. Specifically, dairy output data for Eurostat and ARMS were comparable. Non-dairy output was constructed by subtracting dairy output from total output. It was concluded that the ARMS value for off-farm income earned was conceptually the same as that for the EU. For inputs, it was concluded that the expense items were similarly estimated, but in some cases were included in different categories, thus the different numbers of input variables in the US and EU functions. Previous applications have compared farm productivity measures using both US and Eurostat data, including Ball et al. (2008). The net returns, scale efficiency (RTS, defined in the previous section), and technical efficiency (TE) associated with milk production using the multi-output transformation function framework was estimated for each country. Lastly, a financial-performance comparison of the dairy farms was made by country, technology, and size. Table 1 compares the structural trends in the dairy sector for the countries and the dairy production regions in the US analyzed. Figure 1 identifies the major dairy producing districts by EU country.

Since we are interested in estimating economic performance measures associated with pasture-use groupings, we use a stochastic production frontier (SPF) approach to analyze performance within the groups over the nine-year period, using a transformation function. The SPF results allow for determination of TE and RTS. The SPF measurement involves econometric estimation of a four-output (milk, crops, other livestock, and off-farm income), 10 input (as listed earlier, and six for the US) plus time variable transformation or distance function. We use a pooled approach with all dairy farm observations.

Results

The transformation function estimates by country resulted in >50% of the estimated parameters being significant at the $P \leq 0.10$ level. In addition, the calculation of output elasticities (expected negative signs) and input elasticities (expected positive signs) generally resulted in correct signs for all countries. These results are available on request from the authors. This was uniformly so for the EU countries, but for the US traditional dairy states, the chemicals (pesticides) input elasticity was unexpectedly negative, indicating that increased use of pesticides decreased dairy productivity. Overall, the estimated transformation functions fit the data quite well.

Tables 1 through 8 (See Appendix 1) present the summarized scale and technical performance results by size and technology. We present five herd size categories and three technology cow/ha partitions with important technical and financial information by category. We find that large, higher stocking rate farms generally outperformed smaller farms with lower stocking rates using most economic measures. This is particularly the case with respect to profitability and RTS, but not TE. We discuss each of these in more detail as follows.

Returns to Scale

We find that in most of the countries, RTS trended downward as stocking density increased, indicating greater scale efficiency with more intensive land use. In particular, as the stocking density increased from the well-populated categories of >0.5 to ≤1.5 cows/ha to >1.5 cows/ha, RTS decreased strongly in most countries, particularly Italy and the UK. For example, in Italy, RTS declined from 2.01 to 1.67 and in the UK it declined from 1.62 to 1.39. Furthermore, net return on assets for farms with the highest stocking rates were higher than for farms with medium stocking rates, with the exception of Spain. As herd size increased, RTS trended downward in all seven EU countries, indicating greater scale efficiency for the larger operations. For example, RTS in Germany declined from 1.54 to 1.04 as herd size increased from ≤50 cows to >1,000 cows (see Figure 3).

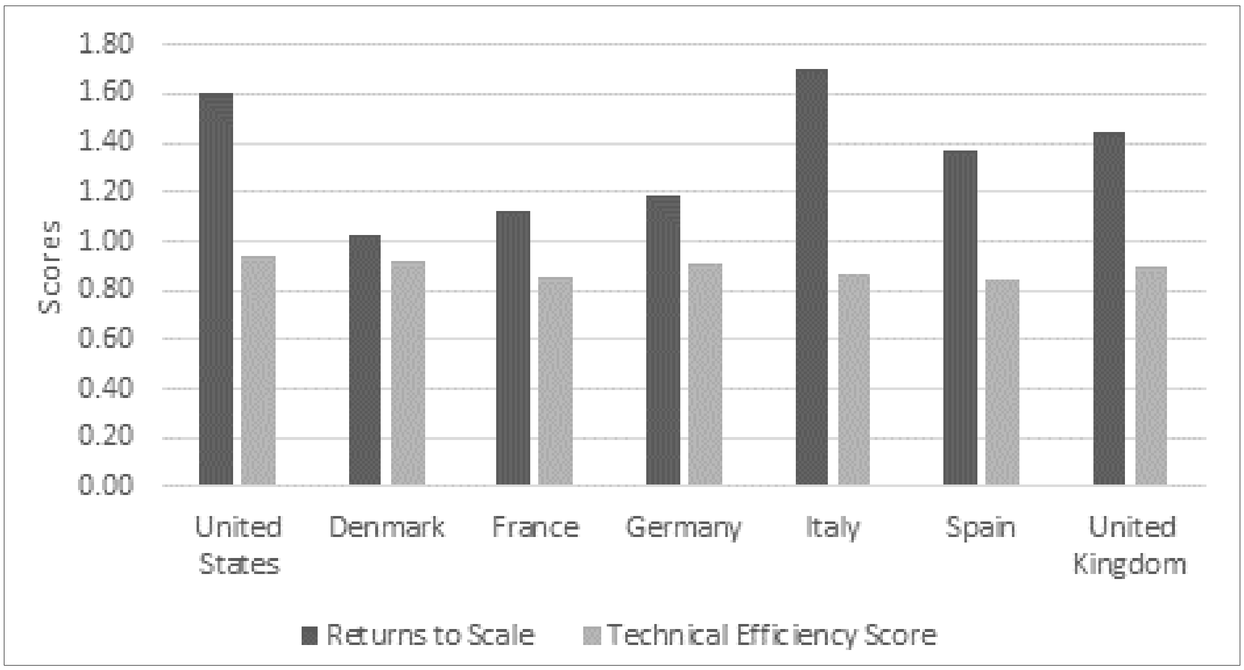

Figure 3. Returns to scale and technical efficiency of dairy operations by country 1999–2007.
Source. USDA–Agricultural and Resource Management Survey (ARMS) and Eurostat

Milk Yield

As herd size increased, milk yields per cow trended upward in all countries. Note, for example, that kg milk produced per cow in Germany increased from 6,070 for the ≤50 cow to 7,843 for the >1,000 cow operations. This is partially due to higher energy feeds used by larger-scale operations, suggested by the increase in feed costs per cow. Note, for example, the US case where feed cost per cow increased from $401/cow for the ≤50 cow operations to $508 for the >1,000 cow operations. Comparing production across countries, the US produced the most milk per cow, with the largest operations (>1,000 cows) producing 11,252 kg/cow, compared with the second-highest large-scale operations (>1,000 cows) in Germany, producing 7,957 kg/cow.

Net Return on Assets

Net return on assets generally trended upward as herd size increased, suggesting greater profitability for larger-scale operations, consistent with economies of scale as shown by MacDonald et al. (2007) for the United States. France had relatively high net return on assets, ranging from 14% to 20% depending upon farm size category. Other regions also having high net return on assets were the UK, Spain, Italy, and Denmark, where net return on assets were >8%. Note that in UK and Germany, the >500, ≤1,000 cow operations experienced 15% net return on assets.

Technical Efficiency

We find no general trend in TE scores by technology or farm size. Farms having the highest TE scores (>0.90) were all sizes of farms in the United States, medium-sized Danish farms, smaller German farms, and the largest Spanish farms, indicating that farms in these categories are producing at levels very close to the stochastic production frontier. The relatively higher TEs among some of the small farms may be the result of their having to pay very close attention to production efficiency in order to remain competitive with larger-scale farms that benefit from economies of scale. United States and Danish farms of all stocking rate categories and more intensive German farms had relatively high (>0.90) TE scores. See Figure 3 for an illustration of TE by country.

Income Diversification

Major differences were not found in farm diversification by country and farm size. The percentage of total farm output from dairy ranged from 66% for Danish >500, ≤1,000 cow operations to 90% for Spanish >500, ≤1,000 cow operations, with the remaining categories falling rather evenly within these boundaries. No clear trends in specialization are noted across all countries, but larger-scale farms tended to be more specialized in Italy, Spain, the UK, and the US. Off-farm income, however, was most important on small-scale (≤50 cows) US farms, accounting for 16% of total income, and larger-scale German farms, accounting for 20% and 17% of household income on >500, ≤1,000 cow operations and >1,000 cow operations, respectively. Off-farm income was least important (contributing ≤1% of household income) on Italian and Spanish farms and on large-scale (>1,000 cows) US farms.

Labor, Feed, and Energy Costs

With the exception of Germany, labor costs per cow generally dropped sharply with farm size as farms became more specialized in dairy and stocking rates increased. Furthermore, milking systems presumably became more automated with farm size. Khanal et al. (2010) showed this to be the case, with larger farms being the greater adopters of four automated technologies. Less clear patterns were seen with feed and energy expenses per cow, though feed expenses in several countries increased with farm size (US, Denmark, Germany, and the UK) along with stocking density and milk production per cow. Figure 4 shows feed and labor costs per cow by country.

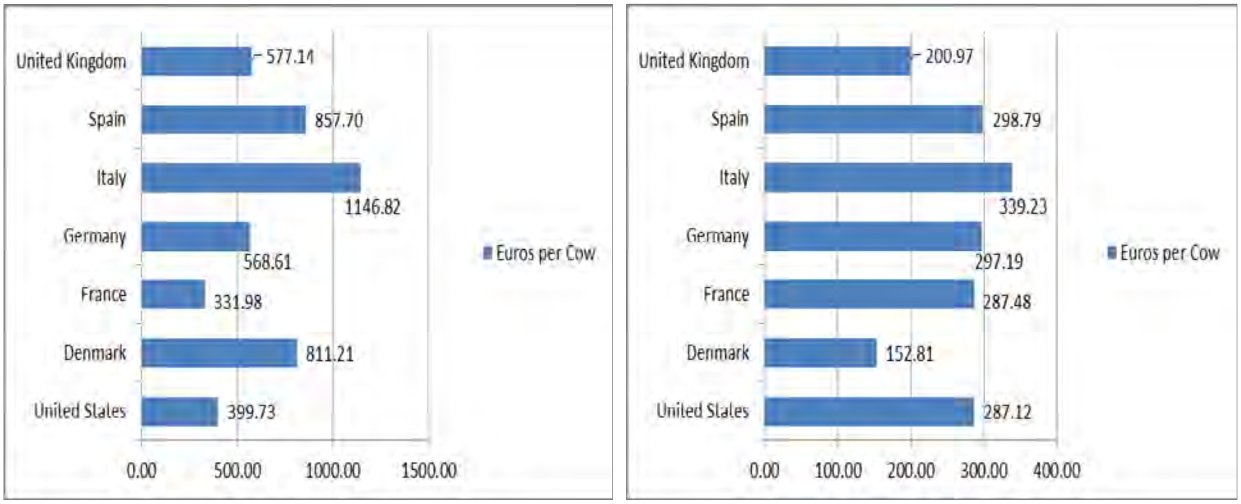

Figure 4. Cost of feed* and labor* per cow on dairy operations by country 1999–2007.
Note. *In Euros; US data converted at an average rate of 1.2 US dollars per Euro.[2]
Sources. Eurostat 2014; ARMS

Conclusions

This study sheds empirical light on dairy production structure in various countries of the EU and the US. Based on a common analytical framework, different quantitative measures derived from an econometrically estimated transformation function are discussed. The aim is to gain insight on the relative competitiveness of the regions by focusing on alternative dairy production systems at the farm level. Dairy industry competitiveness is not solely determined by the competitiveness of the milk production segment, which is the segment on which we focus. Certainly, given that much of trade is in processed or manufactured products, the productive efficiency associated with dairy processing is also important in determining overall industry competitiveness. Further research is encouraged that investigates the competitiveness of the processing segment to gain a fuller picture of dairy industry competitiveness.

The US and most EU countries considered in this analysis show greater dairy farm scale efficiency land is used more intensively, as indicated by increased returns to scale with higher stocking density. Furthermore, an upward trend in farm net return on assets with larger farm size is observed with a few exceptions. Larger dairy operations also show generally greater scale efficiency based on higher milk productivity per cow. In some EU countries, greater degrees of specialization also lead to greater profitability, reflecting economies of scale. The scale of dairy production is positively linked to productivity and profitability over all countries investigated.

However, the empirical analysis also revealed a technically efficient dairy operation does not necessarily require a larger scale or a certain production technology. Highly efficient small scale dairy operations were found in the US and Germany, highly efficient medium-scale dairy operations in Denmark, and highly efficient large scale farms in Spain. This suggests that the relevant competitive edge is still determined to a great deal by regional parameters and structural

[2] https://research.stlouisfed.org /fred2 /data/EXUSEU.txt

conditions in the various countries. The empirical findings for the effects of diversification and off-farm income also point in this direction.

While we have analyzed the productivity of the top two milk producing regions that are also major exporters, we note that several countries outside the EU and the US are also major exporters, most notably New Zealand. Thus, for a full analysis of dairy trade, these countries would need to be included. However, because of the size of the EU and US industries, policies introduced in these regions can have major impacts on dairy trade.

Overall, one can conclude that each of the EU dairy production regions show potential to significantly strengthen their export positions as a consequence of the latest deregulation efforts, namely the milk quota seizure in 2015. Denmark, Germany, Italy, Spain, and the UK show increasing returns to scale and Denmark, Germany, and the UK show higher net return on assets on larger scale farms, suggesting as the farms in these countries expand, they will become more competitive. For the period considered in this study, significant economic forces are at work towards more productive and efficient dairy production throughout the EU. The UK, Germany, and France experienced particularly high net return on assets, returns to scale, and technical efficiency levels that would suggest that increases in farm size and attention to efficiency will significantly influence their productivity. Further deregulation linked with significant milk price fluctuation will likely lead to a reinforcement of these economic linkages between scale, size, cow productivity, and profitability at the farm level as well as total factor productivity and efficiency at the sectoral level. We expect this to result in a faster reallocation of productive resources to more productive and efficient dairy operations, taking into account regional parameters and structural conditions in the various countries. With respect to the US, increasing returns to scale, relatively high milk productivity per cow and technical efficiency, and strong net return on assets among the largest farms will position it to maintain its international competitiveness as a top-five dairy exporter, particularly as farm sizes continue to increase.

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Appendix 1

Table A1. Changing structure of dairy farms in selected EU-27 countries and the United States.

Table A1. Changing structure of dairy farms in selected EU-27 countries and the United States.

Country	Number of Operations			% Change 2000-14	Cows per Farm			% Change 2000-14	Milk per Cow, Kg			% Change 2000-14
	2000	2007	2014		2000	2007	2014		2000	2007	2014	
United States	105,170	75,140	45,344	-56	88	121	204	132	8,257	9,193	10,096	22
Denmark	9,676	4,940	3,622	-63	68	107	151	122	6,930	8,919	9,452	36
France	116,647	97,368	74,397	-36	36	38	50	39	5,623	6,381	6,978	24
Germany	136,000	101,000	77,336	-43	35	41	56	60	6,122	6,944	7,541	23
Italy	97,000	48,487	36,040	-63	35	41	57	63	4,894	5,998	5,623	23
Spain	77,810	37,290	18,798	-75	16	26	46	188	4,964	6,700	7,505	51
United Kingdom	25,944	15,385	14,060	-46	90	130	134	49	6,155	7,175	8,022	30

Sources. USDA Agricultural Statistics, various issues, and Eurostat.

Table A2. US cost of production: means and statistics by pasture usage and herd size.

Item	A *Cows* ≤50	B *Cows* >50, ≤100	C *Cows* >100, ≤500	D *Cows* >500, ≤1,000	E *Cows* >1,000	F *Stocking* ≤0.5 Cows/Ha	G *Stocking* >0.5, ≤1.5 Cows/Ha	H *Stocking* >1.5 Cows/Ha
Observation	337	1,885	4,548	869	382	1,016	3,285	3,720
% of Farms	9.4	42.0	44.7	2.6	1.3	10.5	50.1	39.3
% Value of Production	3.3	20.9	48.6	12.6	14.6	14.8	37.8	47.4
Farm Size and Pricing Information								
Dairy Cows per Farm	46	75	179	683	1,813	167	117	207
Farm Size, Ha	92	111	193	288	242	206	171	114
Land price, $/Ha	6,193	6,067	5,263	5,370	5,948	7,323	4,960	6,353
Technical and Financial Measures								
Milk/Cow, Kg	9,552	9,151	10,087	11,251	11,015	9,086	8,529	10,657
Net Return on Assets, %	5.6	4.9	5.6	6.9	9.7	6.3	5.0	6.6
Stocking Density, Cows/Ha	1.34	1.43	1.93	3.02	5.81	0.22	0.98	3.53
Off-farm % of Total Output	16.1	12.8	6.3	1.5	1.0	5.1	9.4	4.9
Dairy % of Total Output	72.1	76.9	77.2	89.7	85.3	54.9	76.8	81.6
Labor Cost/Cow, $	772.0	549.5	327.8	212.2	122.8	347.8	432.6	273.3
Feed Cost/Cow, $	433.9	433.7	393.6	698.9	631.1	717.4	356.1	504.0
Energy Cost/Cow, $	48.6	44.5	38.0	28.5	16.1	41.8	45.7	26.4
Performance Measures								
Returns to Scale	2.45	1.95	1.24	0.39	0.19	1.56	1.68	1.54
Technical Efficiency Score	0.95	0.95	0.94	0.92	0.94	0.94	0.95	0.94

Table A2. US cost of production: means and statistics by pasture usage and herd size.

Table A3. Denmark cost of production means and statistics by pasture usage and herd size.

Table A3. Denmark cost of production means and statistics by pasture usage and herd size.

Item	A *Cows* ≤50	B *Cows* >50, ≤100	C *Cows* >100, ≤500	D *Cows* >500, ≤1,000	E *Cows* >1,000	F *Stocking* ≤0.5 Cows/Ha	G *Stocking* >0.5, ≤1.5 Cows/Ha	H *Stocking* >1.5 Cows/Ha
Observation	484	1,515	1,735	869			353	3,379
% of Farms	12.9	40.5	46.3	2.6			9.4	90.3
% Value of Production	3.7	36.3	58.1	12.6			9.0	90.6
Farm Size and Pricing Information								
Dairy Cows per Farm	36	76	155	683			99	110
Farm Size, Ha	41	84	152	288			147	108
Rental Rate, Euros/Ha	283	318	495	5,370			173	128
Technical and Financial Measures								
Milk/Cow, Kg	6,629	7,526	7,922	11,251			7,616	7,587
Net Return on Assets, %	6.8	7.8	8.3	6.9			8.1	8.2
Stocking Density	2.95	2.32	2.61	3.02			1.32	2.67
Off-farm % of Total Output	2.8	2.1	3.2	1.5			3.9	2.8
Dairy % of Total Output	78.3	79.7	76.0	89.7			75.3	76.9
Labor Cost/Cow, Euros	258.5	175.1	137.9	212.2			164.7	152.3
Feed Cost/Cow, Euros	700.0	736.8	851.9	698.9			830.3	812.9
Energy Cost/Cow, Euros	74.6	80.4	89.9	28.5			62.3	85.5
Performance Measures								
Returns to Scale	1.56	1.09	0.96	0.82			0.97	1.04
Technical Efficiency Score	0.90	0.93	0.92	0.86			0.94	0.92

Table A4. France cost of production means and statistics by pasture usage and herd size.

Table A4. France cost of production means and statistics by pasture usage and herd size.

Item	**A** *Cows* **≤50**	**B** *Cows* **>50, ≤100**	**C** *Cows* **>100, ≤500**	**D** *Cows* **>500, ≤1,000**	**E** *Cows* **>1,000**	**F** *Stocking* **≤0.5 Cows/Ha**	**G** *Stocking* **>0.5, ≤1.5 Cows/Ha**	**H** *Stocking* **>1.5 Cows/Ha**
Observation	8,074	3,626	480	869		51	6,995	5,134
% of Farms	66.2	29.8	3.9	2.6		0.4	57.4	42.2
% Value of Production	48.3	43.4	8.3	12.6		0.2	51.3	48.5
Farm Size and Pricing Information								
Dairy Cows per Farm	33	67	129	683		28	45	50
Farm Size, Ha	63	110	160	288		99	86	73
Rental Rate, Euros/Ha	128	96	131	5,370		41	80	111
Technical and Financial Measures								
Milk/Cow, Kg	5,798	6,173	6,039	11,251		4,860	5,752	7,587
Net Return on Assets %	13.7	19.9	17.9	6.9		2.1	14.0	8.2
Stocking Density	1.43	1.56	1.56	3.02		0.41	1.14	2.67
Off-farm % of Total Output	3.5	4.3	4.5	1.5		9.1	3.8	2.8
Dairy % of Total Output	67.8	68.8	68.8	89.7		77.5	70.6	76.9
Labor Cost/Cow, Euros	343.8	258.6	170.3	212.2		359.9	293.8	152.3
Feed Cost/Cow, Euros	336.6	339.8	269.8	698.9		322.7	307.7	812.9
Energy Cost/Cow, Euros	93.5	87.7	70.9	28.5		99.0	86.2	85.5
Performance Measures								
Returns to Scale	1.15	1.11	1.11	0.82		1.48	1.13	1.11
Technical Efficiency Score	0.86	0.89	0.86	0.86		0.80	0.86	0.87

Table A5. Germany cost of production means and statistics by pasture usage and herd size.

Table A5. Germany cost of production means and statistics by pasture usage and herd size

Item	**A** *Cows* **≤50**	**B** *Cows* **>50, ≤100**	**C** *Cows* **>100, ≤500**	**D** *Cows* **>500, ≤1,000**	**E** *Cows* **>1,000**	**F** *Stocking* **≤0.5 Cows/Ha**	**G** *Stocking* **>0.5, ≤1.5 Cows/Ha**	**H** *Stocking* **>1.5 Cows/Ha**
Observation	9,352	4,756	1,253	869	55	20	3,815	11, 689
% of Farms	60.2	30.6	8.1	2.6	0.4	0.1	24.6	75.3
% Value of Production	26.5	32.7	22.5	12.6	8.1	0.2	24.2	75.6
Farm Size and Pricing Information								
Dairy Cows per Farm	31	69	172	683	1.260	74	63	63
Farm Size, Ha	41	86	241	288	1,784	334	125	72
Rental Rate, Euros/Ha	204	238	141	5,370	105	66	99	221
Technical and Financial Measures								
Milk/Cow, Kg	6,070	7,006	7,372	7,843	7,957	5,382	6,237	6,562
Net Return on Assets %	2.1	5.7	4.2	14.7	12.4	0.0	3.4	5.5
Stocking Density	1.90	2.00	2.12	1.97	2.49	0.41	1.21	2.20
Off-farm % of Total Output	10.5	4.9	7.2	19.7	17.3	18.0	12.6	8.7
Dairy % of Total Output	74.9	77.8	78.9	68.8	72.3	70.1	75.1	76.2
Labor Cost/Cow, Euros	360.1	226.5	248.2	404.0	400.2	357.7	353.2	279.1
Feed Cost/Cow, Euros	429.1	470.1	547.8	882.4	746.7	575.6	527.0	529.0
Energy Cost/Cow, Euros	183.3	169.9	191.5	265.8	232.3	291.7	229.0	178.2
Performance Measures								
Returns to Scale	1.54	1.31	1.31	1.12	1.04	1.39	1.26	1.17
Technical Efficiency Score	0.90	0.92	0.91	0.89	0.88	0.87	0.90	0.91

Table A6. Italy cost of production means and statistics by pasture usage and herd size.

Table A6. Italy cost of production means and statistics by pasture usage and herd size.

Item	A *Cows* ≤50	B *Cows* >50, ≤100	C *Cows* >100, ≤500	D *Cows* >500, ≤1,000	E *Cows* >1,000	F *Stocking* ≤0.5 Cows/Ha	G *Stocking* >0.5, ≤1.5 Cows/Ha	H *Stocking* >1.5 Cows/Ha
Observation	9,662	2,251	1,317	29	12	954	2,573	9,744
% of Farms	72.8.	17.0	9.9	0.2	0.4	7.2	19.4	73.4
% Value of Production	29.3	24.4	39.7	2.9	0.1	3.8	8.7	87.5
Farm Size and Pricing Information								
Dairy Cows per Farm	23	71	182	635	1,499	33	25	57
Farm Size, Ha	29	57	82	206	709	172	37	28
Rental Rate, Euros/Ha	67	131	270	520	155	223	733	252
Technical and Financial Measures								
Milk/Cow, Kg	4,824	6,398	7,169	6,449	6,659	3,655	4,520	5,707
Net Return on Assets %	7.8	9.1	10.5	9.9	8.8	11.0	8.1	9.2
Stocking Density, Cows/Ha	3.29	5.53	131.75	10.02	9.78	0.27	1.05	22.08
Off-farm % of Total Output	2.3	0.8	0.4	0.9	---	2.7	2.8	0.1
Dairy % of Total Output	68.8	73.7	76.0	81.5	74.2	79.2	76.3	86.5
Labor Cost/Cow, Euros	586.4	297.7	184.3	153.0	133.1	535.8	577.8	307.0
Feed Cost/Cow, Euros	1024.4	1121.0	1268.0	1172.0	1107.8	920.3	1042.8	1167.0
Energy Cost/Cow, Euros	106.8	112.7	114.4	108.7	123.1	67.9	108.3	114.3
Performance Measures								
Returns to Scale	3.51	1.22	1.30	1.28	1.11	1.61	2.01	1.67
Technical Efficiency Score	0.87	0.88	0.88	0.84	0.82	0.85	0.86	0.87

Table A7. Spain cost of production means and statistics by pasture usage and herd size.

Table A7. Spain cost of production means and statistics by pasture usage and herd size.

Item	A *Cows* ≤50	B *Cows* >50, ≤100	C *Cows* >100, ≤500	D *Cows* >500, ≤1,000	E *Cows* >1,000	F *Stocking* ≤0.5 Cows/Ha	G *Stocking* >0.5, ≤1.5 Cows/Ha	H *Stocking* >1.5 Cows/Ha
Observation	8,438	2,286	587	3	---	553	1,635	9,127
% of Farms	74.6.	20.2	5.2	0.3	---	4.9	14.5	80.7
% Value of Production	47.4	33.3	18.9	0.4	---	7.2	9.8	83.0
Farm Size and Pricing Information								
Dairy Cows per Farm	28	68	182	624	---	70	30	42
Farm Size, Ha	18	31	45	157	---	26	40	18
Rental Rate, Euros/Ha	93	113	111	115	---	62	67	119
Technical and Financial Measures								
Milk/Cow, Kg	5,758	6,842	7,596	6,903	---	6,234	5,561	6,155
Net Return on Assets %	5.6	8.3	10.5	4.5	---	18.0	12.9	7.0
Stocking Density	3.42	7.21	22.25	2.40	---	0.07	1.12	6.19
Off-Farm % of Total Output	0.3	0.5	0.6	---	---	0.6	0.3	0.4
Dairy % of Total Output	79.2	86.2	87.6	90.0	---	87.8	77.9	83.3
Labor Cost/Cow, Euros	393.9	220.1	167.1	163.4	---	196.7	354.2	301.1
Feed Cost/Cow, Euros	804.2	871.2	975.1	572.2	---	636.3	782.4	885.8
Energy Cost/Cow, Euros	60.8	62.0	66.9	25.1	---	48.8	66.8	62.9
Performance Measures								
Returns to Scale	1.45	1.33	1.26	1.00	---	1.29	1.62	1.35
Technical Efficiency Score	0.83	0.84	0.84	0.90	---	0.83	0.82	0.84

Table A8. United Kingdom cost of production means and statistics by pasture usage and herd size.

Table A8. United Kingdom cost of production means and statistics by pasture usage and herd size.

Item	**A** *Cows* **≤50**	**B** *Cows* **>50, ≤100**	**C** *Cows* **>100, ≤500**	**D** *Cows* **>500, ≤1,000**	**E** *Cows* **>1,000**	**F** *Stocking* **≤0.5 Cows/Ha**	**G** *Stocking* **>0.5, ≤1.5 Cows/Ha**	**H** *Stocking* **>1.5 Cows/Ha**
Observation	1,410	2,249	2,290	21	---	9	998	4,963
% of Farms	23.6.	37.7	38.4	0.4	---	0.2	16.7	83.1
% Value of Production	7.5	29.3	63.9	2.0	---	0.01	11.2	90.6
Farm Size and Pricing Information								
Dairy Cows per Farm	36	75	165	629	---	46	68	109
Farm Size, Ha	51	78	138	370	---	329	124	90
Rental Rate, Euros/Ha	239	239	301	308	---	10	167	318
Technical and Financial Measures								
Milk/Cow, Kg	5,411	6,327	7,015	6,892	---	5,222	5,826	6,489
Net Return on Assets %	7.6	8.8	10.7	14.5	---	5.2	8.2	9.8
Stocking Density	1.85	2.09	2.37	2.63	---	0.40	1.22	2.33
Off-Farm % of Total Output	3.6	2.3	2.4	0.9	---	6.3	4.2	2.2
Dairy % of Total Output	73.0	70.2	81.9	89.0	---	62.3	75.2	79.2
Labor Cost/Cow, Euros	306.7	196.0	145.6	100.5	---	372.1	459.3	165.0
Feed Cost/Cow, Euros	473.2.	509.7	561.6	509.4	---	636.9	545.3	537.8
Energy Cost/Cow, Euros	103.8	84.6	93.1	63.1	---	117.5	100.2	78.4
Performance Measures								
Returns to Scale	1.71	1.49	1.35	1.32	---	1.94	1.62	1.39
Technical Efficiency Score	0.86	0.88	0.89	0.84	---	0.83	0.88	0.88

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Factors Influencing the Dairy Trade from New Zealand

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Introduction

Most dairy products in the world are consumed in the region or country in which they are produced. This is hardly surprising as milk and its various derivatives are highly perishable products. Milk also provides important nutrients in the diets of many communities so is a key plank of food security and hence protectionist legislation. Trade in a large quantity (46%) of milk is informal (IDF 2015) through short supply chains, and even with the formal trade most milk does not cross currency borders. Global trade in milk therefore, in most countries, involves milk that is surplus to a country's requirements. In 2014, the share of globally-traded (crossing currency borders) dairy products was just 9% of overall production. Because the total volume of international trade in dairy is small, it is considered to be a "thin market" and small imbalances in supply or demand can "shake" or disrupt the market (IFCN 2015).Of the globally traded dairy products, just four exporting regions cover 70–80% of the trade with New Zealand, the largest, accounting for up to a third.

In New Zealand (NZ), in stark contrast to other milk producing countries, less than 4% of its milk is consumed within the country. It has a small population (4.47 million) and produces more than 21 billion liters/year. Its customer/client base is therefore predominantly off shore and mostly, but not exclusively, includes those countries that are not self-sufficient in dairy. The focus of NZ dairy is, therefore, global by definition and the factors influencing dairy trade are global, although within NZ there are also societal and political influences on production and processing. This paper will first present global dairy trends with respect to how they have and do influence NZ dairy and then will drill down to one geography before describing specifics of the NZ dairy scene and global and local issues that are currently having the most impact.

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Global Dairy Trends

World cow and buffalo milk production increased by 38% from 2000 to 2014 with cow milk growing at a compound average growth rate of 2.2% and buffalo milk at 3.3% (IDF 2015). Combined cow and buffalo milk production grew from 559 million tons (MT) in 2000 to 769MT in 2014 with the OECD–FAO (OECD–FAO 2016) estimating 831 MT in 2017 (Figure 1). Regions with the highest cumulative average growth in cow milk production from 2000–2014 were Asia (4.9%), Africa (4.4%) and South America (3.1%), mainly due to increases in the number of dairy animals and farms. In 2014, as in previous years, the top milk-producing regions were Asia (28%), EU (24%) and North and Central America (18%). In terms of specific countries the largest milk producers continue to be India (141 MT), and USA (93 MT). With a milk production of 21.3 MT, New Zealand accounted for just 3% of global milk production in 2014.

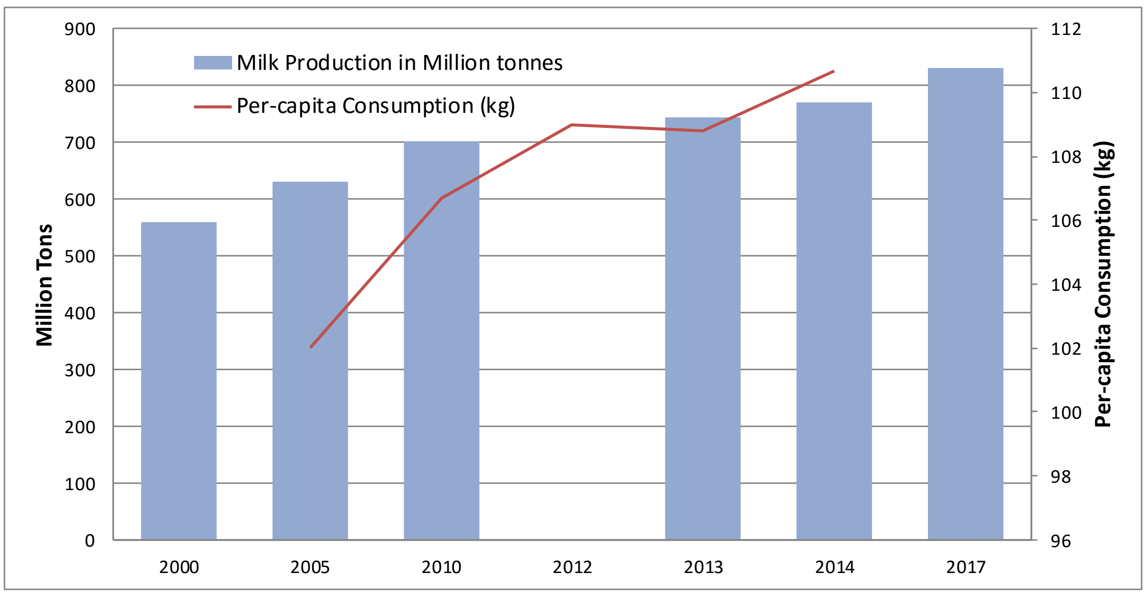

Figure 1. World milk production and per capita dairy consumption
Source. International Dairy Federation (IDF) 2015; OECD–FAO 2016

Increased production was driven by an increase in demand created by both an 8.5% increase in per-capita consumption (Figure 1) and a global population increase of 10% from 2000 to 2014. Asia (337 MT) and Europe (201 MT) were the largest dairy consumption regions accounting for 43% and 26% of world dairy consumption respectively in 2014 (IDF 2015).

Both growth in per-capita consumption levels and growing wealth in Asia implies potential for future growth in Asian dairy demand and consequently in domestic supply and world trade (Dong 2006). According to OECD-FAO Agricultural Outlook projections global dairy consumption is expected to increase by 21% by 2025 (OECD-FAO 2016) with per capita consumption increases forecast of 1.7% and 1.1% per annum for fresh dairy and whole milk powder respectively in the developing world.

Despite growth of organized dairy (specifically in the developing regions of the world), a large part (46%) of dairy consumption is the result of informal trade. Of the remaining 54%, fresh milk and dairy products account for 17%, followed by butter (15%),cheese (13%), whole milk powder (WMP) (4%), skim milk powder (SMP) (3%) and other (2%) (Figure 2). With economic progress it is expected that the share of milk that passes through the formal sector will increase.

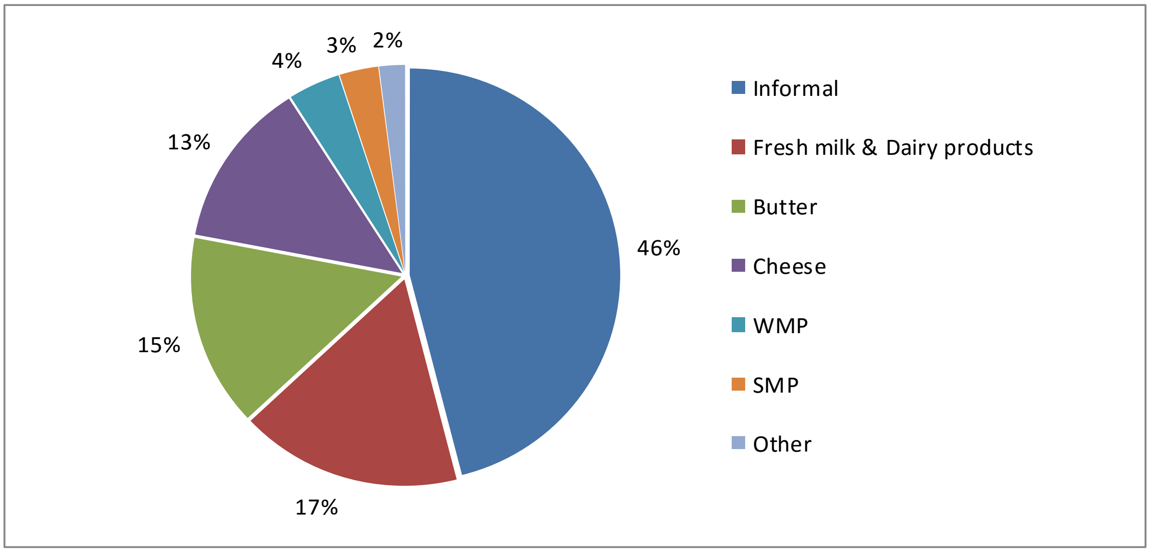

Figure 2. World dairy consumption– by product type.
Source. (IDF 2015)

Trade

Cross border trade of some dairy products is significant. For example, in 2011, almost 80% of WMP production and 50% of SMP production was traded internationally (IDF 2012). The OECD-FAO projection is that by 2025 this will still be high at 61% and 49%, respectively, with New Zealand's share of WMP world trade remaining at 54% (OECD-FAO 2016). For such product categories (having a high trade to production ratio), a relatively small change in supply-demand balance of milk can have a significant impact on the dynamics of trade as witnessed in WMP when China (which held 28% of world import share in 2014), dropped its imports 34% from 2014-15 (OECD-FAO 2016). This phenomenon, along with the impact of protectionist legislation, act as an important source of volatility in global dairy markets.

Dairy Exports and Imports

Although the world dairy industry is extremely fragmented, when it comes to international trade, the market is quite concentrated with the top four supplying regions covering 70–80% of the world's total export volume (IDF 2015). However, on the demand side the market remains fragmented.

Currently, New Zealand is the largest exporter of dairy in the world and accounts for 28% of world trade. The other key exporters are the EU (26%), US (14%) and Australia (6%). Since the year 2000, New Zealand and the United States have seen an increase in their share of world dairy trade, while both the EU and Australia have seen a decrease (Figure 3). New Zealand in 2014 was the largest exporter of WMP and butter and butter oil, while the EU was the most significant exporter of cheese, SMP and whey.

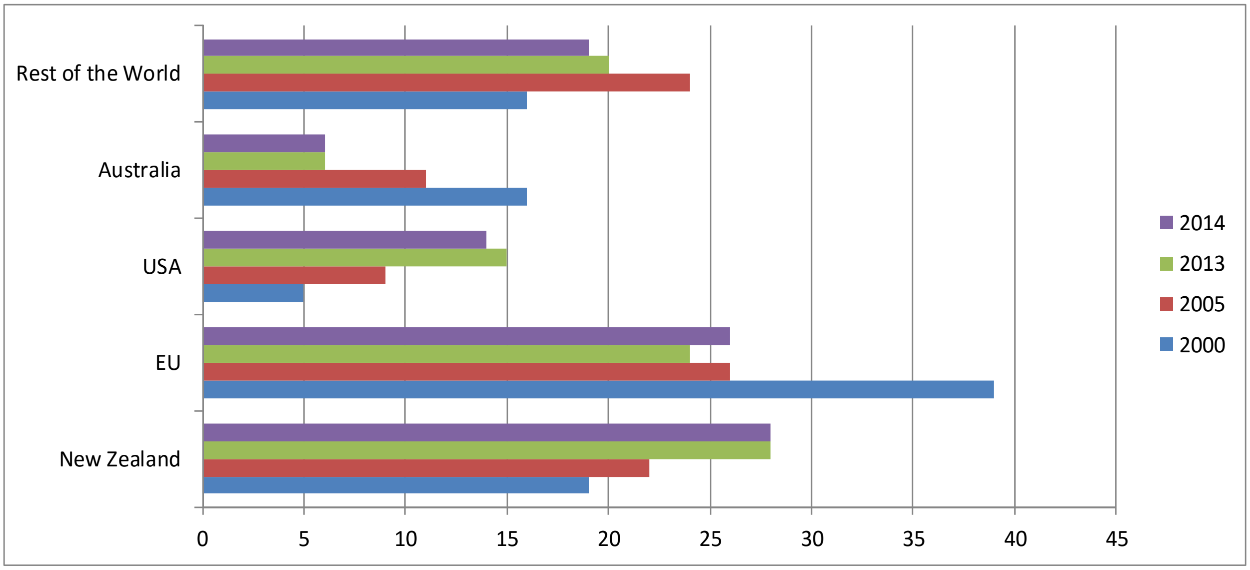

Figure 3. Export share of key dairy exporters–over time (%)
Source. International Dairy Federation (IDF) 2015

On the import side, the mix of nations is quite variable and is product dependent. Russia has been the largest importer of cheese and butter (oil), and China the largest importer of WMP, SMP, and whey. Other significant importers are Japan (Cheese), China (butter oil), Algeria (WMP), Mexico (SMP) and Russia (whey).

The self-sufficiency rate, defined as the ratio of a country or region's share of global milk production and global milk consumption, is an important factor that influences the degree as well as the direction of trade flows. From 2005 to 2014, the only region to report a decrease in self-sufficiency has been Asia. In 2014, Asia with a 38.4% share of world production and 42.9% share of world consumption had a self-sufficiency rate of 90% (IDF 2015).

Dairy Industry

The global dairy industry is extremely fragmented with the top twenty-one processors accounting for just 21% of world milk production. The industry is dominated by many small players that operate at the regional/local level. In terms of revenue/turnover (in Billion USD from dairy alone), the top five dairy companies in 2014 were Lactalis (21.9), Fonterra (18.7), Nestle (18.3), DFA (17.9) and Friesland Campina (15.0) (IDF 2015). Furthermore, there were twenty-five dairy companies (located in eleven countries) that recorded a dairy turnover exceeding 3.5 billion USD (IDF 2015). A unique feature of the dairy industry is that these companies can just as likely be clients of each other or working in strategic alliances in certain markets as competing with each other with branded products. The cooperatives, who commit to pick up all milk produced by their members, are more often the companies that provide ingredients to other companies as well as develop their own brands. In recent years there have been significant mergers, acquisitions and strategic alliances between various players as they jockey for position in the growth of global dairy trade.

The leading customers for dairy products in the formal market are food retailers, the food service industry and the food processing industry. The products they purchase range from branded products (mostly regional with few global brands) to ingredients with a wide range of higher value specialized ingredients in between. Base ingredients, commodities, are traded on various derivative markets including the NZ Stock Exchange (NZX) and the Chicago Mercantile exchange (CME). The prices attained on these markets often form the reference point for more specialized ingredients' values and for the price paid to farmers for their milk.

The NZ Dairy Industry

Historically, the New Zealand dairy industry has been dominated by co-operatives, and this continues to be the case. Currently, co-operatives account for nearly 95% of New Zealand's milk production, with New Zealand's largest company the Fonterra Co-operative group alone accounting for about 85% of NZ milk production. However, as a result of the expansion in global demand for milk and new dairy products and encouraged by NZ legislation (described in the next section), New Zealand has increasingly become a destination for global dairy companies for sourcing quality milk and producing dairy products. This has been reflected in an increase in Foreign Direct Investment in dairying and milk processing in New Zealand in recent years, and it now accounts for over half of all disclosed agribusiness investments, with 31% in milk processing and 20% in dairying (KPMG 2015).

In 2014, for example, several foreign firms either entered or consolidated their presence in the NZ dairy sector. The French firm Danone, through its subsidiary Nutricia, acquired a milk drying plant (Gardians) and a packaging operation (Sutton Group). The Dutch dairy cooperative Friesland Campina, increased its stake in the New Zealand dairy company Synlait by 2.5%, raising its shareholding from 7.5–10%.

In 2014/2015, there were three dairy related investments by Chinese firms in NZ. The Chinese dairy company Yili, which reported a turnover of 8.8 billion USD in 2014, purchased the NZ dairy company Oceania Dairy in 2013 and is in the process of constructing a new milk powder and UHT milk factory in New Zealand. The Yashilli group made a $212 million investment in a milk processing plant that will manufacture infant milk powder products. On the farming side, SFL holdings have acquired Synlait Farms for $85 million. In general, Chinese investment in NZ reflects a strong focus on dairy (KPMG 2015).

Apart from foreign firms and investors, New Zealand-based dairy companies have also made significant investments in milk processing and product manufacture. In order to be better placed to make a product mix that delivers improved returns to its NZ farmers and meet the needs of its global consumers and customers, the Fonterra Cooperative Group has made investments to the tune of US$1.1 billion in New Zealand since 2012 (CNIEL 2014). The majority of this investment (US$870 million) has been in milk powder manufacture with smaller investments made in cheese manufacture (US$130 million) and UHT milk production (US$100 million) (CNIEL 2014). Of the other NZ based dairy firms, the cooperative Tatua made a NZ$65.5

million investment in a new dryer in 2014. The South Island based dairy cooperative Westland invested NZ$114 million in an infant nutrition plant and NZ$40 million in a UHT milk production plant. Synlait, a listed dairy company with significant Chinese ownership, also in the South Island invested $100 million in 2011 in a dryer.

New Zealand currently exports dairy products to nearly 140 countries. As there is no uniform consensus and agreement on market access requirements across countries NZ dairy processors cannot produce a product of a single specification and hope to export it to all their markets. Instead they need to produce products keeping in mind the specific market access requirement of the destination market/country. This adds another layer of complexity and challenge for NZ dairy exports. Apart from the specific known market access requirements, NZ exporters also need to be aware of the local context of import markets and work closely with the NZ government to predict possible hurdles to market access that might be introduced.

The Legislative Background

In 2001, the Dairy Industry Restructuring Act 2001 (DIRA) was passed that enabled the establishment of Fonterra, a merger of two dairy co-operatives (Kiwi Co-operative Dairies Limited, the New Zealand Co-operative Dairy Company Limited) and the New Zealand Dairy Board. The form that Fonterra took was determined in part by legislation and in part by changes to the constitution approved by co-operative members at Fonterra's inception.

DIRA provided for significant ongoing constraints on Fonterra's behavior to address concerns about the possible competitive effects of the merger. One of the primary constraints placed on Fonterra by DIRA was the requirement of "open entry and exit" at fair value as described by Shadbolt and Duncan (2016). DIRA also required that Fonterra must make up to 5% of its milk production available to independent processors at a regulated milk price that references Fonterra's farmgate price. This was to ensure that NZ consumers could be served by a variety of providers, not all of whom needed to have the capability to pick up milk. The rationale for this regime was also to keep barriers to entry for new competitors sufficiently low to promote a competitive price for milk at the farm gate, despite the fact that as a cooperative Fonterra has an imperative to pay the highest milk price to its owner-suppliers on a long-term sustainable basis.

Fonterra's constitution determined that shares were issued and surrendered at their "Fair Value." The motivation for this change stems from "free-rider" tensions within the Co-operatives during the phase of rapid industry expansion in the last half of the 1990s which required substantial investment in new processing capacity. Fonterra also determined the rules by which it sets its farmgate milk price (which ultimately determines its share price). The Global Dairy Trade (GDT) auction platform was implemented in July 2008 to provide an objective reference point for the setting of Fonterra's Farmgate Milk Price and hence improve price transparency. Fonterra sets one average farmgate price, based on five reference products sold on GDT, for the whole season's supply of milk. This final price evolves over the season as market demand and exchange rates vary, so it is not determined and paid in full to the farmers until after the end of the season.

The China Factor

New Zealand dairy exports to China have increased substantially over the last seven years, enabled by the NZ-China Free Trade Agreement (NZ-China FTA). Domestic milk production in China increased 9.3% per year from 2004 to 2009, but after a food safety issue in 2008 there was no growth (-0.7% per year) so imports were required to meet their increasing demand (IDF 2015). The demand increase saw the value of NZ dairy exports to China increase significantly from 21% of total exports to 46% in 2013 (Figure 4). Supply, and to a lesser extent demand, shocks have had a big impact on exports. Undersupply, due in part to animal disease outbreak in China, led to the sharp increase in imports and price spikes in 2013/14 (Figure 5). Farmer response (unfettered in the EU post quota removal) to the price spike (unfettered in the EU post quota removal) led to oversupply in 2015. This plus inventory and demand issues led to a 34% decrease in WMP imports by China (OECD-FAO 2016) and a subsequent correction in global dairy price.

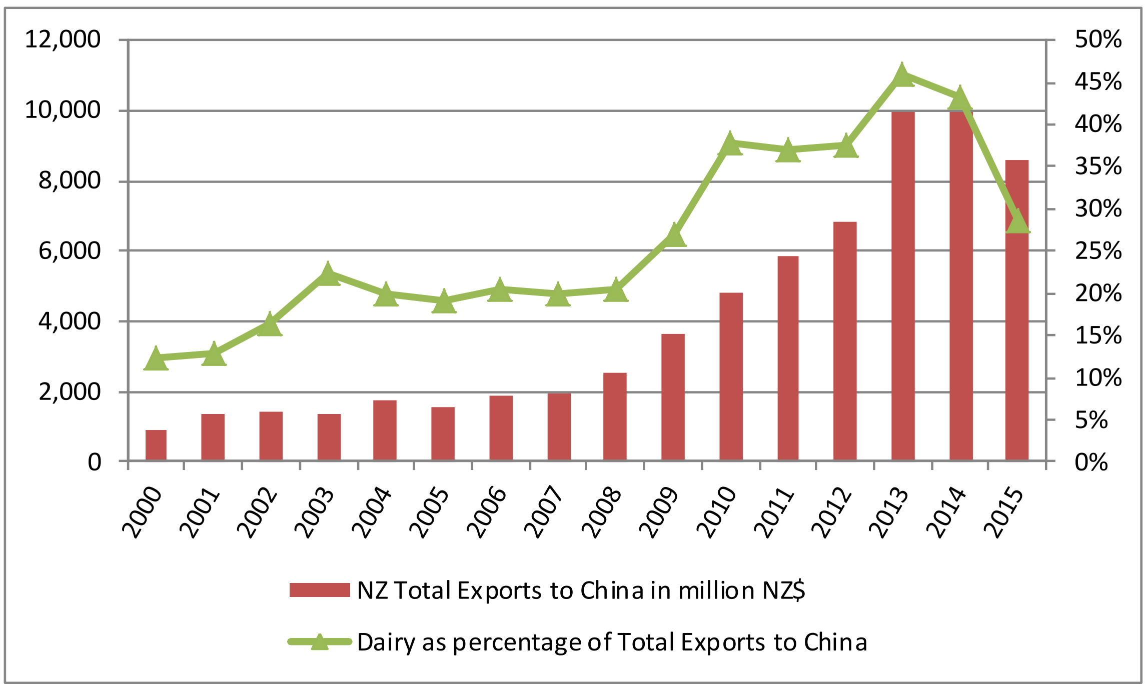

Figure 4. NZ total exports to China and dairy exports as a percentage of the total.
Source. NZ Statistics (2016)

Despite the correction in 2015, China's economic growth, increasing urbanization and growing household incomes, combined with limitations in its own dairy sector, continue to deliver opportunities to the New Zealand dairy industry. China's domestic supply, estimated at 30.3 million tons in 2014 (IDF 2015), is insufficient to meet its growing demand. The Chinese government has initiated reforms and implements programs that enable productivity and production improvement that also address animal health and food quality issues. This has included requiring importers of dairy product to invest in the dairy industry in China to assist in the development of safe, high-quality Chinese dairy products.

Milk Production in New Zealand

Over the last twenty years milk production in New Zealand has increased by 127% from 9.3 billion liters (1995–1996) to 21.3 billion liters (2014–2015), and grown at an average rate of 4.7% per dairy season (SD = 4.6%) (Figure 5). During this period, variation in milk production by year were more related to climatic conditions than market conditions (IFCN 2015), a significant point of difference of NZ dairying. The steady climb in milk production, despite short-term price variation, indicates a longer term perception of the opportunities in dairying. Analysis of NZ dairy farmers' perceptions of risk by Shadbolt and Olubode-Awosola (2013) observed an interesting combination of perceived threats from global economic and political situations with perceived opportunities from global supply and demand indicating a perspective of NZ dairy farmers commensurate with global players in an international market.

The rapid increase in milk production has had some unintended consequences within NZ. The environmental impact of higher stocking rates especially on free draining soils and under irrigation, or in high rainfall areas, is now being closely monitored and controlled. As NZ environmental legislation is outcome driven, the farmers are being tasked with delivering to increasingly tighter specifications which have resulted in significant investments on the farm to improve water quality. Society also has a heightened awareness of animal welfare and labor issues. Despite being an agricultural nation, urbanization has increased the lack of understanding of farming and farm practices, hence the stronger scrutiny.

Farmgate milk price volatility has increased since 2007 as can be seen in Figure 5. While the average price since 2007 is 70% higher than the preceding years, the volatility is 150% more. With over 96% of milk products exported the vagaries of both global markets and exchange rates have a significant impact on price achievement.

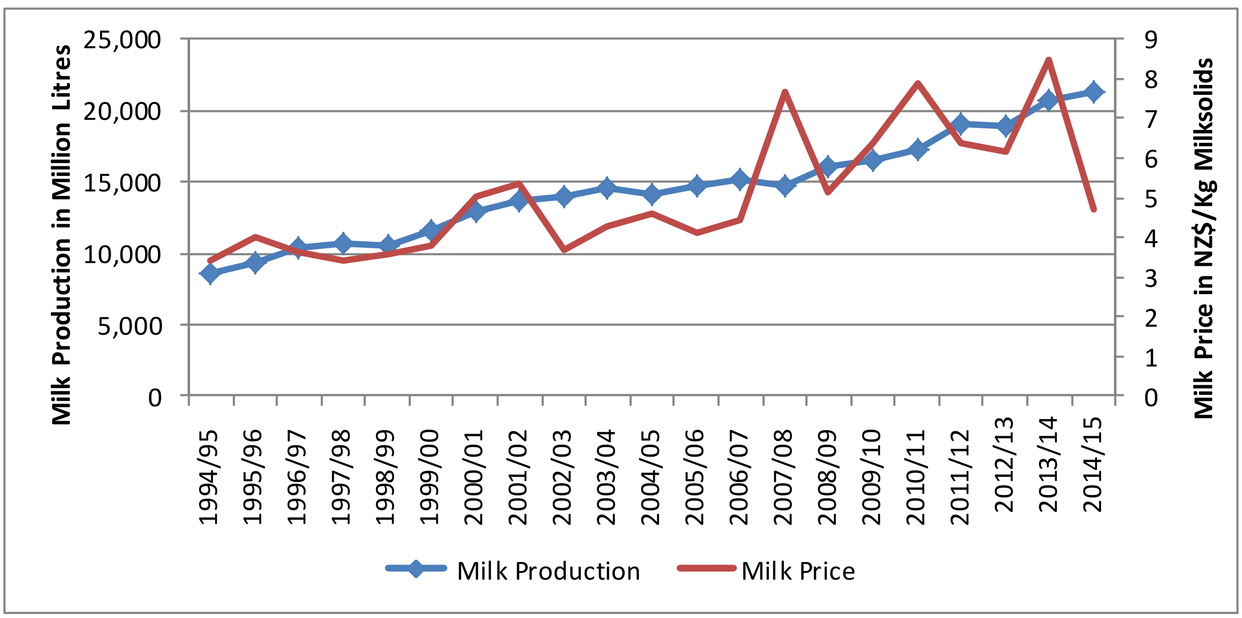

Figure 5. NZ milk production and price trends
Source. LIC (2015)

Farmers achieved this increase in milk production by increasing cow numbers and the area of land under dairying from 1980/81 to 2014/15 (Figure 6). The average annual growth rate for cows was 2.7% (SD = 2.2%), while the growth rate for the area under dairying was 1.7% (SD = 2.6%). From 1980/81 to 2007/08, the number of dairy herds decreased by 170 herds per season but then increased due to more conversions of non-dairy farms to dairying. In 2014/15 there were 11,970 dairy farms, 5.02 million dairy cows and 1.746 million hectares under dairying in New Zealand (LIC 2015). The average farm size in terms of cows was 419 and in terms of hectares were 146 ha. Much development of dairy farms this century has occurred in the South Island that now has 26% of farms and 39% of cows and milk production; and has larger farms, many of them irrigated.

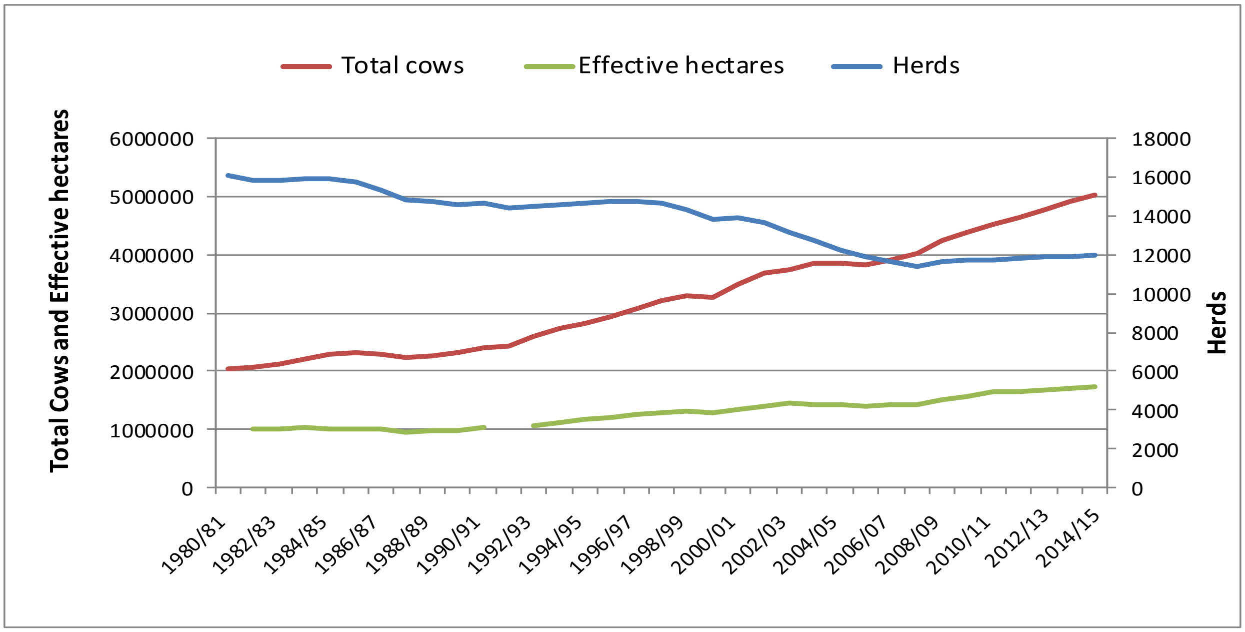

Figure 6. NZ–Trends in number of cows, herds and area under dairying
Source. New Zealand Dairy Statistics 2014–2015 (LIC 2015)

Optimism in dairying has resulted in increases in land prices, conversions of land to dairy and significant on-farm investment with a commensurate increase in dairy sector debt from $11.3 billion to $37.9 billion between 2003 and 2015 (Dunstan et al., 2015) representing 10% of total NZ bank lending. Farmland in NZ has a much higher turnover than in many countries, and multiple forms of ownership and management structures have evolved since 2003 as farmers have built equity (Reekers et al., 2007). The 'home' farm can now be the base for a number of equity partnerships or sharemilking contracts on other farms. While farmland values increased it was possible to gain leverage on debt but when milk prices decrease, land prices can adjust down putting debt at risk. But, as outlined by Dunstan et al. (2015), a combination of low-interest rates and a positive long-term outlook for milk prices have supported land prices throughout 2015. However, based on their estimate that 49% of farmers did not break even in the 2014/15 season, and that 80% could have a negative cash flow in the 2015/16 season, they suggest a weakening of land values is possible.

Seasonality–A Unique Feature of New Zealand Milk Supply

In the extensive pasture-based farm systems of New Zealand cows are free range and not housed. Pasture growth is dependent on climatic conditions and has a distinct seasonality curve (Figure 7) and varies according to climate, specifically rainfall and temperature. Pasture growth is most abundant and reliable in Spring (September to November), lowest in Winter (June to August) and least predictable in the summer (December to March).

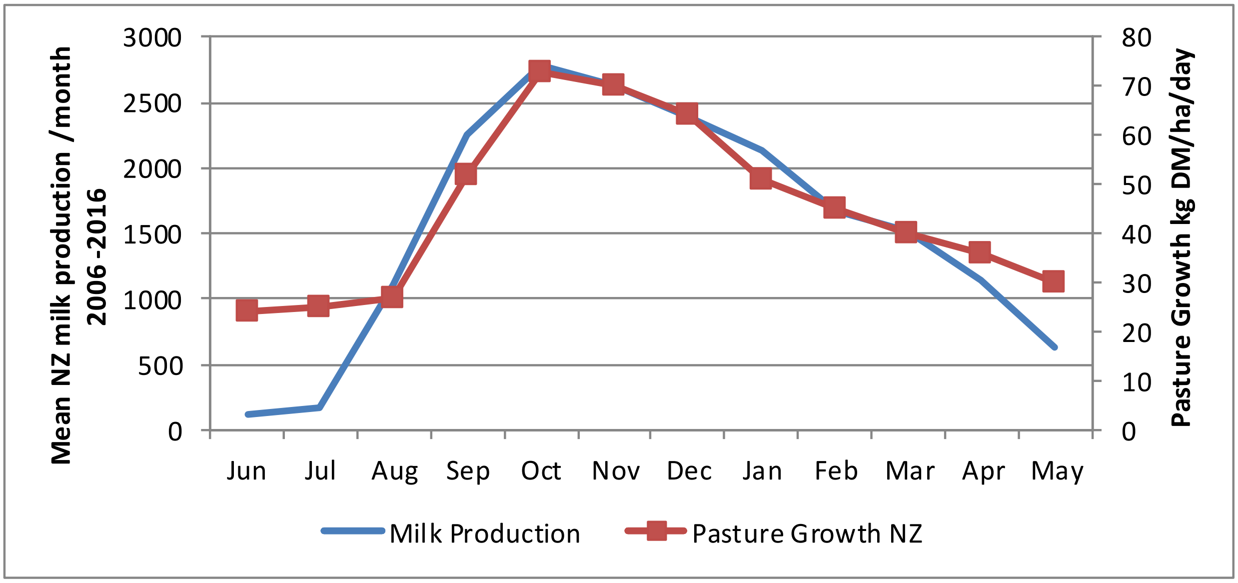

Figure 7. Typical pasture growth curve of NZ and Mean NZ milk production per month
Source. DairyNZ (Ruakura -16.4t DM/ha /year); DCANZ 2006–2016 (www.dcanz.com).

Since milk production in New Zealand is driven by available pasture and forage crops, it too follows a distinct seasonal pattern with the shape of the milk production curve being a reflection of pasture seasonality (Figure 7). In practice, the milking season in New Zealand starts in August (with cows calving) and ends in May (with cows being dried off). This ensures that the period of a herd's maximum feed requirement (at potential peak milk production and based on a tight calving pattern) is alignmed with the period of maximum pasture growth in spring. Few farms produce milk during the winter months of June and July. The low levels of milk produced during the months of June and July (termed "winter milk") primarily supply the domestic dairy market with fresh dairy product and the export of shorter shelf-life products such as UHT milk.

Milk output from pasture shows distinct variability both in volume and quality, with a lower degree of control over intake and diet quality and hence cow performance expected in pasture-based feeding systems (Gazzarin et al. 2011). The standard deviation around the mean milk production illustrated in Figure 7 shows variation up to 14% during the months of September to March and up to 25% in the shoulder months. Milk produced from pasture also shows higher variability in fat and protein content over time; a lower proportion of saturated fatty acids (Wyss et al. 2011) and lower total somatic cell counts than milk from indoor systems. Such variability, coupled with the normal changes in milk composition over lactation, which are concentrated by seasonal production, provide challenges for the processor.

The processing industry, in response to the seasonal production curve, has evolved to efficiently make long-life products from milk at peak – powders (WMP, SMP), cheeses, whey products and fats (butter and AMF). With milk production at peak nearly twenty-five times that of production in mid-winter the processing plants operate at varying levels of capacity through the season. The optimal product mix for NZ to manufacture is based on the relative values of the various products. In recent years the powder prices have dominated resulting in all processors (existing and new) increasing dryer capacity. Powder manufacturing in NZ has achieved significant economies of scale, the Fonterra Darfield D2 dryer producing at 30 tons per hour (www.fonterra.com). The relative value of cheeses, whey products, and fats with respect to powders varies from year to year, so optimizing production requires variable use of the existing capacity in NZ. More perishable products such as soft cheeses and UHT milk require a more constant milk supply so they are less suited for strong seasonal supply curves and are catered for to a lesser, but growing, degree by additional processing capacity.

Farmer Decisions that Influence the Milk Supply Curve

As pasture growth is reliant on the weather, variability of feed supply is common. As outlined above variability in farmgate milk price is also common with the final price not known until after the end of the production season. In order to profitably balance the supply and demand of feed, dairy farmers in New Zealand use a range of management practices. If pasture is in short supply later in the season, farmers will reduce feed demand by milking once a day, reduce the number of cows on the milking platform by drying off early and culling unproductive cows. They might also feed supplements (grass or maize silage or palm kernel extract) if available and economic to do so. Earlier in the season, they will attempt to boost pasture growth by applying nitrogen fertilizers and also use feed supplements if available and economic to do so. When pasture is abundant, farmers will conserve surpluses into silage and hay and make every effort to keep cows in lactation as long as possible. When milk prices are trending favourably farmers might carry more cows and purchase more supplements to meet any feed deficits, and vice versa. Interestingly, if pasture is available but milk prices are low cows will still be milked, this response is due to their high fixed-cost system, and is contrary to farmer responses in the higher variable-cost systems of the EU and US. Other than those farmers carrying higher cow numbers, when milk prices vary they are not as influenced by milk–feed price ratios as US and EU farmers. Instead, production is influenced by pasture availability which, for all but the irrigated farmers, is determined by rainfall. Farmers in New Zealand aim to optimize production per unit area (hectare), instead of production per cow, as is more common in intensively housed systems.

Cost of Production–The NZ Advantage

The International Farm Comparison Network (IFCN) produces a comparison of cost of milk production by country and presents their findings annually. In the IFCN reports New Zealand has historically and continues to have the lowest cost of production along with other Southern hemisphere countries that also export into the global markets. In 2014, the average costs of production for New Zealand were around US$37/100kg milk while that in Western Europe and North America were around US$61/100kg milk and US$53/100 kg milk respectively (IFCN 2015). In that year the prices achieved were not dissimilar between countries resulting in NZ farmers being very profitable. Since then prices have decreased significantly, although global price signals took longer to be reflected in US and EU farmgate prices. At such levels profit is elusive to almost all dairy famers in the world.

Following milk price increases in 2007/08, NZ dairy farmers increased their spending. Costs of production, operating expenses, went from $3.70 to over $5/kg milk solids (Hammond 2016). While some farmers intensified, moved up the cost curve, producing more milk with more cows and bought in feed, others just spent more. Commentary in the NZ farming press suggests intensification removes NZ's competitive advantage but initial analysis by Shadbolt (2012) further extended by Hammond (2016) show the cost of production per kilogram of milksolids being no different across both low input and higher input systems. The challenge as milk prices fall is to decrease cost of production per unit of milk. This is not as simple as just reducing costs. Recent analysis has identified how in pasture-based farms where the majority of costs are fixed, this is best achieved by those who successfully harvest more grass and therefore produce more milk from those fixed costs (ANZ 2016). Pasture and grazing management skills are a necessity when prices are low. Reducing cow numbers, and reducing the use of imported feed when marginal feed costs are higher than the price of milk, is a given. Preliminary IFCN cost of milk production only estimates for 2014/15 indicate a 16% reduction (Shadbolt, pers comm.). DairyNZ (2016) report a further decrease in net costs[1] of 10% in response to lower milk prices in 2015/16 and predict an additional 4% for 2016/17. While the break-even price they calculate is still above the predicted milk price it does illustrate the ability of NZ farmers, in the absence of any government support, to respond quickly to global milk prices.

For those farms with high debt levels servicing that debt is an additional fixed cost. As outlined earlier dairy farm debt has increased, with debt to asset percentages increasing from 35% to 46% in the last ten years (DairyNZ 2016a). However the impact of this debt has been softened by decreases in interest rates during the same time period such that interest and rent paid as a percentage of gross farm income has reduced from 23.5% to 21.5% despite interest and rent paid per kilogram of milksolids increasing from $1.08 to $1.36 over those same ten years. Decreases in milk price, production levels and land price all worsen the metrics used to determine vulnerability of businesses—ultimately it is the cash flow of the farm and the ability to manage discretionary spend that determines the robustness of the business. In depth analysis over six years of data by Shadbolt and Olobude-Awasola (2013) determined that debt and its various metrics were not the distinguishing factor in business success over time, instead it was the operating profit margin, the ability to flex with the seasons adjusting expenditure to revenue.

Future Scenarios

Uncertainty is a fact of life in NZ dairying. However significant investments are made both on and off-farm based on a view of the future. A recent scenario analysis exercise by the Centre of Excellence in Farm Business Management (Shadbolt et al. 2016) identified the common view of the future and compared that with three other possible, plausible futures. The rationale for this exercise was a belief that too many farming systems were being developed around the 'common view' with a strong on-farm focus, paying little attention to emerging global trends, other than the growing demand for dairy.

The futures identified in the scenario analysis reflect the interpretation of sixteen specific local and global uncertainties. The analysis involved a multitude of stakeholders to arrive at four

[1] including farm working expenses, interest and rent, tax and drawings; and net of livestock and other income received. Excluding unpaid family labour and depreciation.

possible plausible future scenarios that the NZ dairy industry could be operating in in ten-years-time (See Table 8). These scenarios include: **1) Base Case**—increased complexity, competition and volatility, **2) Consumer is King**—the volume to value revolution, **3) Governments Dictate**—political chaos and shrinking markets and **4) Regulation Rules**—it is our "privilege to serve". The scenarios developed describe a range of futures. No attempt was made to assess the relative probability of these futures, and each of these futures is deemed possible and plausible. Shadbolt et al (2016) concluded that the future is most likely to contain a mix of elements from the various scenarios, and it is probable that the future will lie somewhere between the four scenarios. The base scenario reflects the current trends but the setting is delicately balanced, hence, each of the four scenarios is equally relevant to the industry.

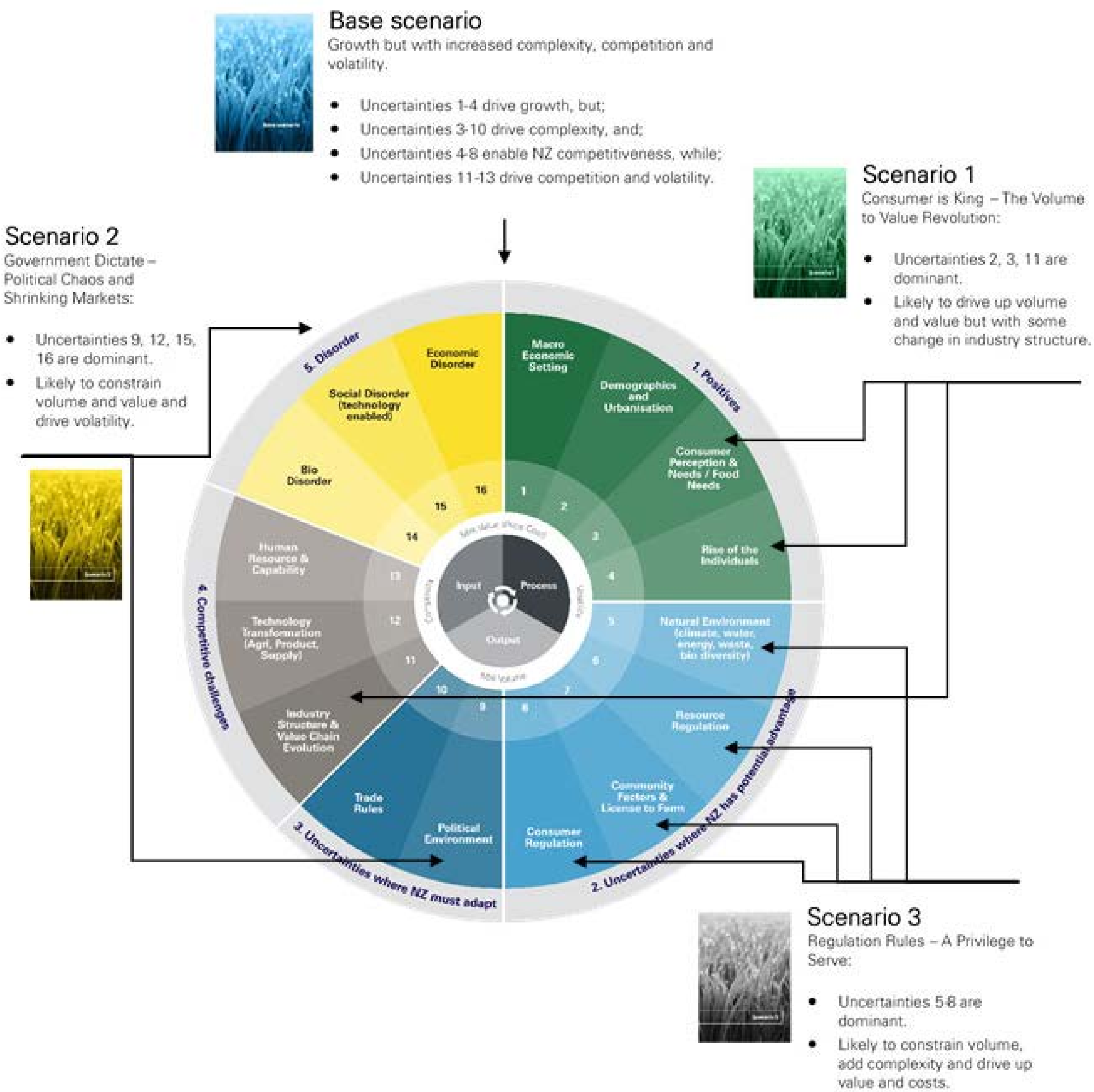

Figure 8. Four Scenarios for the NZ Dairy Industry developed from sixteen uncertainties.
Source. Shadbolt et al. 2016

Overall, each scenario presents challenges to the NZ dairy industry which indicates that changes are required across the NZ dairy value chain in order to thrive and be resilient across the scenarios described.

Conclusion

New Zealand is a global trader in dairy by definition so must pay heed to changes in global supply and demand. Within NZ the dairy industry must also ensure it minimizes its environmental footprint and is exemplary in its treatment of animals and staff. Despite being a major contributor to the nation's wealth, it cannot take its freedom to operate for granted. While well positioned to take advantage of the forecast increase in demand for formal trade in dairy products in Asia, in particular, it is challenged by the high trade-to-production ratio for most of its products. Although it is a major player in global dairy trade it is challenged by the thinness of the market and the impact that quite small supply or demand shocks can have on world price. The reliance on rainfall provides an additional complication to seasonality of production with processors running plants at varying levels of capacity throughout the season. Ultimately it is the ability of the integrated dairy chain, from NZ to all of its various markets, to flex with the uncertainties of production and prices, local and global issues, and achieve returns for all players that does and will determine its success. It is this ability to produce milk competitively that has enabled NZ to establish itself as a major player in global dairy markets.

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