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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).

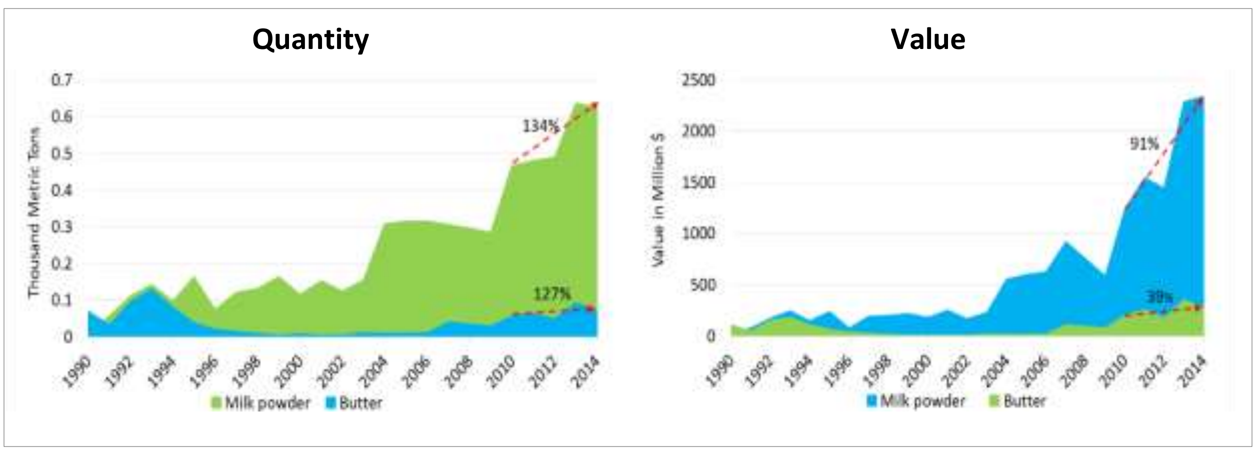

Figure 1. Worldwide trends in US dairy export quantity and value, 2010–2014

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.

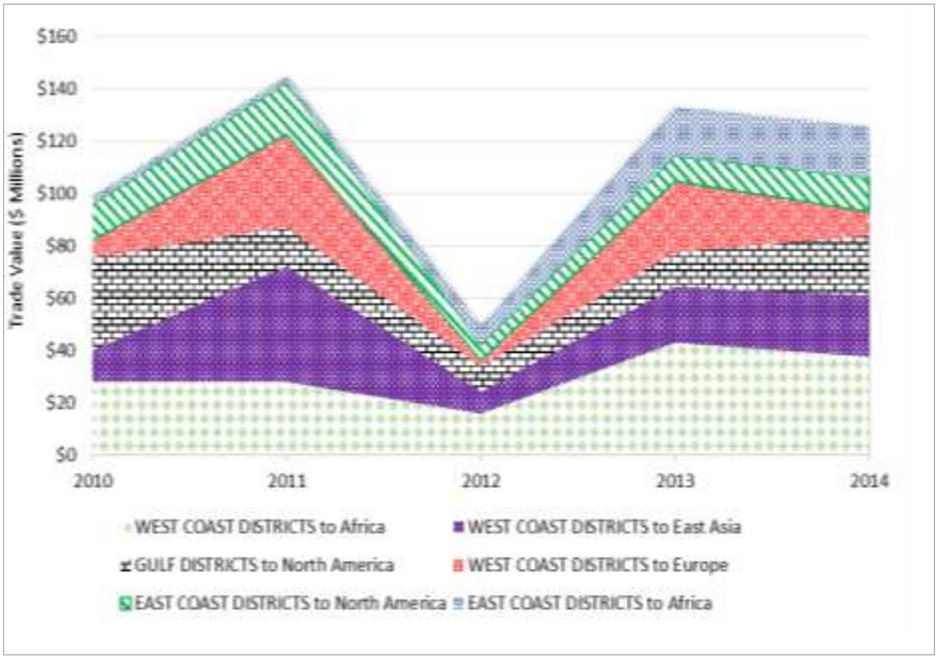

Figure 2. Top regions and export destinations for butter (export value), 2010–2014

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.

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

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 Origin	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**
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%.

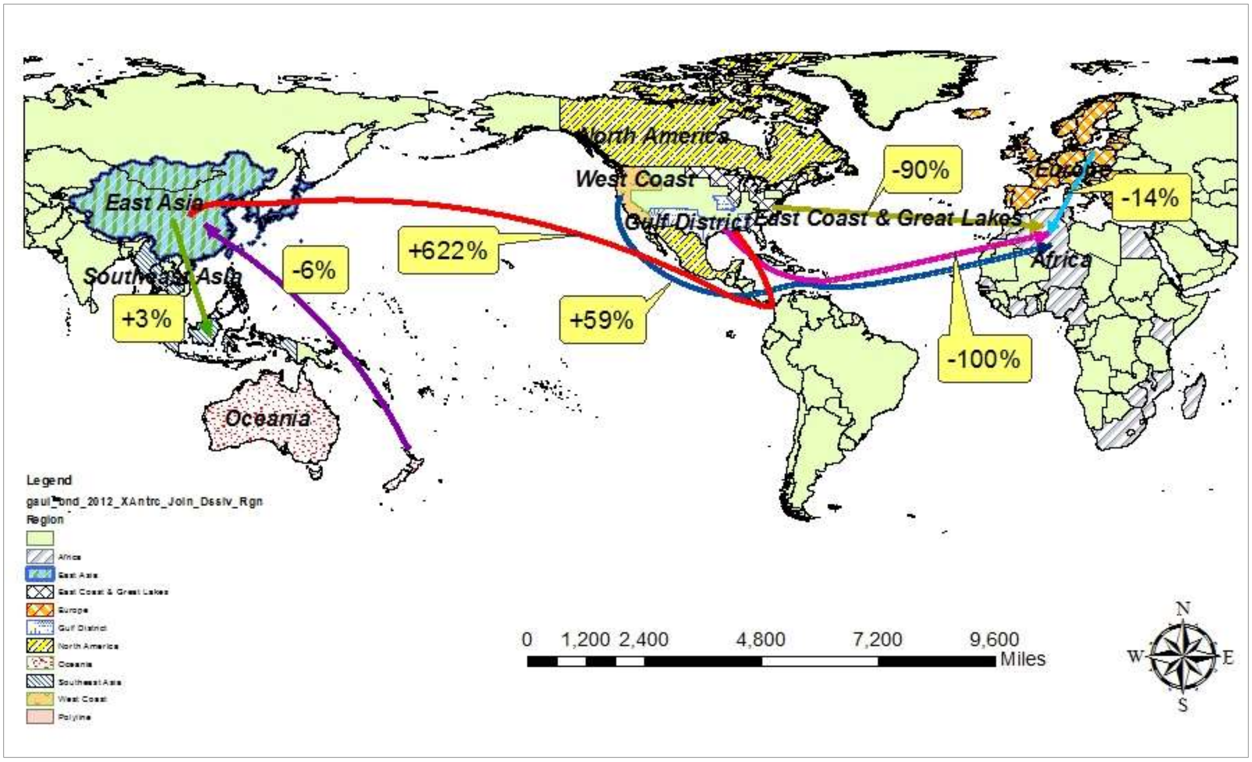

Figure 3. Dry milk domestic bilateral trade percentage changes simulation results
Source: ERSI World Countries 2014[2]

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	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
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.

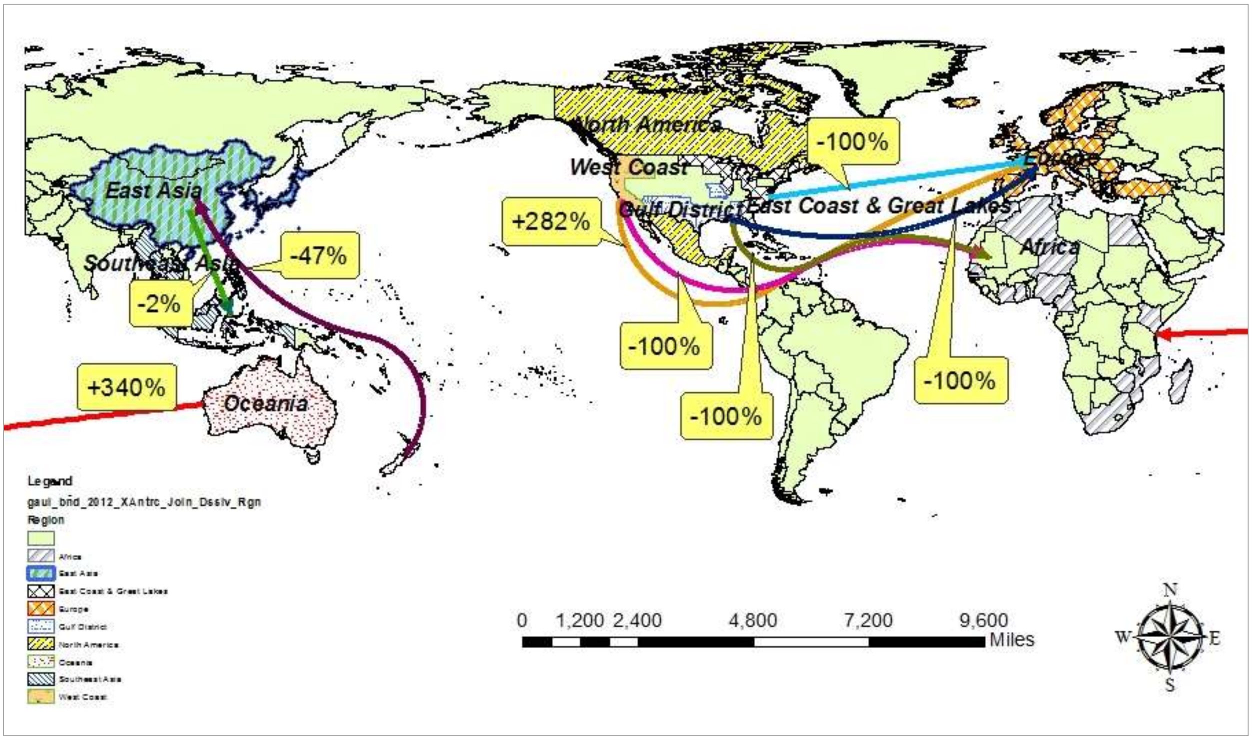

Figure 4. Butter domestic bilateral trade percentage changes simulation results
Source. ERSI World Countries 2014 [3]

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