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Understanding the Consequences of the Panama Canal Expansion on Midwest Grain and Agricultural Exports

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16. Abstract The Panama Canal Authority (ACP) is currently building a third lock scheduled to open in 2014, significantly changing the capacity of the canal for inter-ocean movements. Midwest specialty grain and agricultural product exporters will be directly affected as all-water routes are improved and landbridge requirements reduced. The study assesses the expectations of public and private sector stakeholders, analyzes possible changes in greenhouse gas emissions and energy consumption, and examines potential economic impacts the expansion may cause in these commodity sectors. Findings suggest that the canal expansion may decrease transit times, incentivize export to Asia via Gulf Cost ports and containerized modes, increase greenhouse gas emissions and energy consumption, and a diminished competitive position for the US West Coast - intermodal route.			
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Executive Summary

The Panama Canal is a vital conduit for maritime shipping to and from the United States, including grain exports from the Midwest. The current expansion of the Canal's capacity is expected to have significant impacts on agricultural supply chains. With the construction of a third set of locks underway and scheduled for completion by 2014, the Canal will be capable of accommodating more and larger bulk and container ships, creating the potential for greater economies of scale, reduced delays, and greater feasibility for all-water routes.

The Midwestern United States currently produces approximately 75 percent of the nation's corn, wheat, and soy; 60 percent of the nation's agricultural exports originate in the region. In particular, Illinois and Iowa are dominant producers and exporters of coarse grains. As demand expands in less-developed markets and macroeconomic trends point towards more favorable currency valuations for exporters, grain is anticipated to remain an important piece of American exports. With export volumes projected to rise in coming years, future changes in the transportation network that moves agricultural commodities abroad—including the expanded Panama Canal, competing ports, and the inland waterway and surface modes that support maritime freight—deserve serious assessment. To that end, this project examines the expected impacts of the expansion project on the Canal's operations, as well as interactions with trends in the agricultural and freight sectors.

In order to determine the impacts of the expansion project on agricultural exports, the project team employed both quantitative modeling methods and qualitative examination of existing literature, economic trends, and expectations of the agricultural production and transportation industries. Researchers used both production and commodity flow data to characterize current grain movements. These data also served as a basis for GIS-based analysis of energy consumption and greenhouse gas emissions. The project team also collected and distilled expectations from industry associations, federal agencies, and industry analysts.

Although there is considerable uncertainty among grain transportation professionals and industry observers on the effects of the Panama Canal expansion, it is likely that the expansion project will result in faster transit times and lower waiting times, lowering the time costs of the all-water route for grain. Growth in grain export volumes from the Pacific Northwest and Gulf Coast is anticipated to outpace California's volumes, and increasing quantities of specialty grains will be moved in containerized modes. In the longer term, the ability of the new set of locks to move much larger vessels may prove significant to exporters' decisions to ship grain from Gulf Coast ports. However, limitations on the size of vessels that Gulf and East Coast ports can accommodate will, in the near term, limit opportunities for grain exporters to use post-Panamax bulk and container ships. Finally, an increase in export volumes shipped through the Panama Canal is anticipated to increase associated CO_2 emissions and oil consumption, compared to exports leaving from the West Coast.

Introduction

Since opening in 1914, the Panama Canal has been a vital part of international trade. However, the growth of worldwide shipping over the course of the last century has increasingly strained the Canal's capacity, causing the Panama Canal Authority (ACP) to estimate in 2006 that the Canal would reach its current operating capacity sometime before 2012.[1] This capacity squeeze resulted in significant waiting times and demand for reserved transit slots, a problem compounded by the Canal's size limitations.

At present, the Canal can accommodate the operation of vessels of up to 965 feet (294.1 meters) in length, 106 feet (32.3 meters) in width (beam), and 39.5 feet (12 meters) in depth (draft).[2] Accordingly, vessels of this size are called Panamax, reflecting their status as the largest ships able to navigate the series of locks. Ships larger than the Panamax standard now operate along most major trade routes but exceed the limitations of the canal's lock system. In response to rising demand for international shipping and the increasing prominence of these "post-Panamax" vessels, canal authorities proposed a major canal expansion that was overwhelmingly approved by the citizens of Panama in a referendum on October 22, 2006.[3]

The proposed expansion, currently under construction, will add a third set of locks to the canal system, as well as deepening and widening existing channels (for a more detailed technical overview of the Canal expansion, see Ried, R.L., 2007). These new locks will be able to accommodate much larger post-Panamax ships that are expected to dominate the route with dimensions of up to 1200 feet (366 meters) in length, 160 feet (49 meters) in beam, and 49 feet (15 meters) in draft.[2] When completed, the expansion promises to reduce wait times and cut shipping costs through the Panama Canal. A new toll structure, combined with decreased transit times and larger vessels, may affect the shipping dynamics of a wide variety of products.

This project examines the potential shifts in the shipping patterns of Midwestern grain and agricultural products—much of which currently moves through the Panama Canal—and subsequent impacts on greenhouse gas emissions, energy consumption, and production and transportation choices of agricultural exporters. To maximize comparability to existing and future research, "Midwestern" grain is defined as originating in the ten states of the Mid-America Freight Coalition: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. In order to investigate these potential changes, researchers deployed a variety of methods: spatial analysis of grain production and transportation based on statistics from sources such as the US Department of Agriculture (USDA), Federal Highway Administration (FHWA), and Panama Canal Authority (ACP); interviews with industry experts; a survey of Midwestern grain exporters; and modeling of energy consumption and emissions for different modes affected by the Canal expansion.

Canal Operations

The Panama Canal was built and operated by the United States from its opening in 1914 until December 31, 1999, when, under the terms of the Torrijos-Carter Treaty signed in 1977, control was transferred to the Panama Canal Authority. During and after the lead-up to the transfer, the Panamanian government and ACP began planning for the future of the Canal and examining responses to continued growth in traffic. Even though usage has steadily increased over the years, the third set of locks is the first major expansion to the original configuration. The United States undertook an expansion similar to the current one in 1939, but work was stopped on account of the second World War.[2] However, the current project makes use of channels partially dug during the American expansion.

Although the third set of locks project constitutes the largest expansion of the Canal to date, targeted improvements intended to accommodate growing traffic and increasingly large vessels

have been undertaken from time to time. From the 1980s onward, a number of projects intended to increase capacity—widening the Gaillard Cut, deepening Gatun Lake and other areas of the Canal, and upgrading canal equipment—have been successfully completed.[2]

Shipping Volumes

The ACP estimates that the Canal presently holds a 38 percent market share of containerized shipping between Northeast Asia and the East Coast of the United States.[1] In the containerized market the Canal's primary competitors are the intermodal US system and the Suez Canal. ACP also estimates that the expansion with the third set of locks will boost this market share to nearly 50 percent. Given the rising trend in containerized grain shipping, Midwest grain may well become a major portion of these transits.

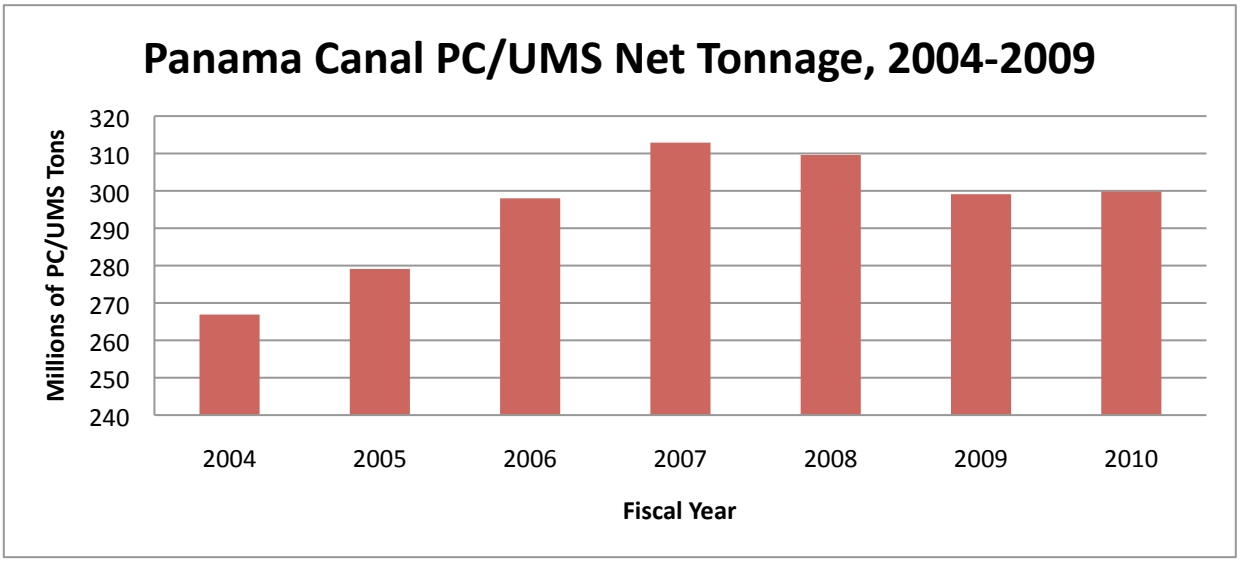

Figure 1: Panama Canal Historical Tonnages

In FY 2010, over 299 million PC/UMS (Panama Canal Universal Measurement System) tons of cargo passed through the Panama Canal.[4] Of this, 161.5 million tons (53.8 percent) were shipments originating from the East and Gulf Coasts of the United States and bound for destinations via the Pacific Ocean. Furthermore, Atlantic-to-Pacific grain shipments accounted for more than 37 million long tons moved in 2010, equivalent to 31 percent of all Atlantic-to-Pacific trade through the canal and 17 percent of all transited freight by weight. The ACP's transit statistics show that grain shipments originating from the eastern and southern United States are a sizable and important piece of the Canal's traffic.

Canal Water Time

Canal Water Time (CWT) is a measure of the time a shipment takes to navigate the Canal, including the time that a cargo ship spends waiting in a queue for passage. Because transit time is relatively static once a ship enters the system, fluctuations in CWT are generally due to lengthy wait times. Wait times for access to the canal have averaged around 12 hours in the past few years but vary widely by traffic conditions, and can range from a few hours to a day or more. By comparison, transiting the Canal itself generally takes around ten hours. Thus, CWT is often used as a metric for congestion and queue performance.

The Canal operates based on a two-tiered system. Ships may purchase a reserved slot, which guarantees transit at a predetermined time. Those ships without a slot reservation must wait for unreserved slots at the entrance to the canal. Although the canal tracks both reserved and overall CWT, the overall CWT is the most commonly cited measure of the Canal's performance.

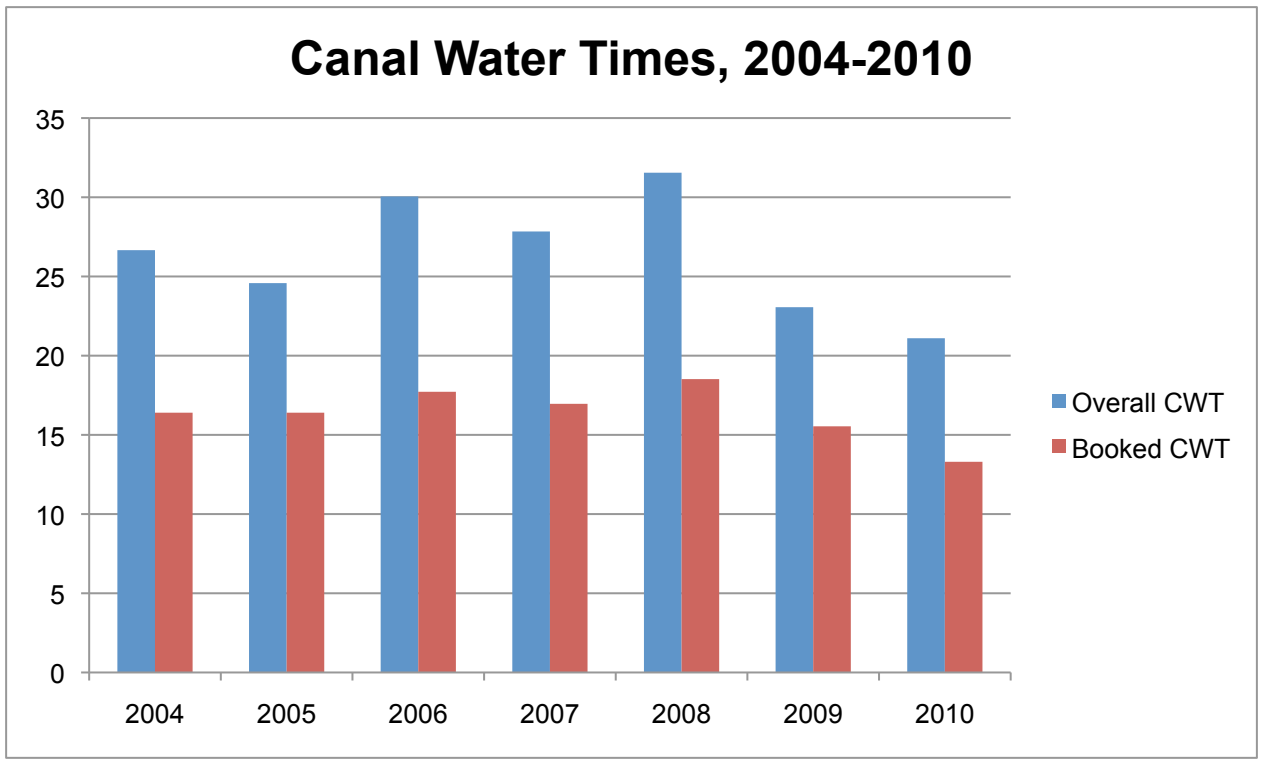

Figure 2: Historical Canal Water Times

Reserved slot CWTs have ranged from 7.8 to 13.0 hours shorter than the average CWT. In 2010, ships without reservations waited an average of 11.4 additional hours compared to booked vessels. Furthermore, overall CWT has shown greater variation year-to-year than booked CWT.

Because grain and other agricultural exports tend to be of lower value than many commodities transiting the Panama Canal, shippers and carriers are unlikely to be able to justify paying steep premiums for reserved transit slots. They are therefore subject to longer and more volatile transit times, increasing time costs and decreasing reliability of grain shipments. An expanded Panama Canal with faster transit times will therefore be a significant boon for agricultural exporters.

Grain Exports: Modes and Volumes

The Midwestern United States is a vital agricultural producer for the nation and the world, particularly for grain crops. The USDA's National Agricultural Statistics Service (NASS) reports production volumes and estimates export values for various agricultural products including wheat, feed grains, and soybeans. The MAFC region's estimated share of wheat exports is significant but not dominant, accounting for 33.1 percent of the nation's trade in 2009. In the feed grain and soy sectors, the region's products account for 67.6 percent and 68.3 percent, respectively, of US exports.[5]

Within the MAFC region, the ten member states produce widely varying shares of exported crops. Across the three categories of soy and grain reported by NASS, Illinois and Iowa claimed the largest export shares, accounting for nearly a quarter of all US exports and more than a third of the region's.

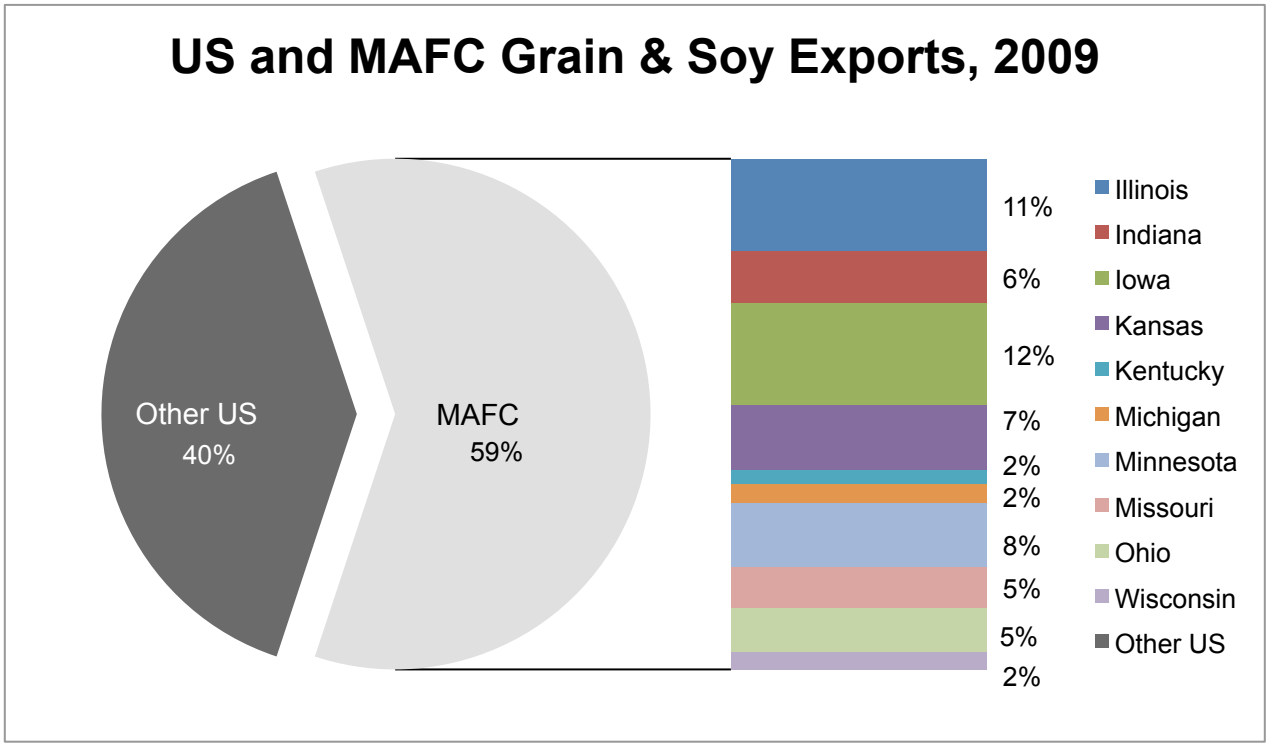

Figure 3: US and MAFC Grain and Soy Exports

Focusing on grains, as traced from producer state to port and beyond by the FHWA's Freight Analysis Framework (FAF) data, an examination of the path that exports take from field to consumer highlights the importance of the Panama Canal to the United States and its agricultural sector.

Domestic Grain Production

An understanding of the paths US grain takes to its international destinations starts with the places where it is produced. The USDA tracks grain production at the county level across the United States. Midwestern counties account for a majority of the top corn and wheat producing counties in the United States. In 2008, states within the Mid-America Freight Coalition (MAFC) region—Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin—accounted for 79.1 percent of corn, 80.6 percent of soy, and 40.1 percent of wheat produced in the United States. In total, almost three quarters of this crop originates in this region.

According to USDA measures, Iowa and Illinois are the two most significant sources of coarse grain in the United States, dwarfing every other state and accounting for nearly a third of production by themselves. If the other MAFC states are included, the Midwest share of coarse grain production jumps to nearly three quarters of the US total.[5]

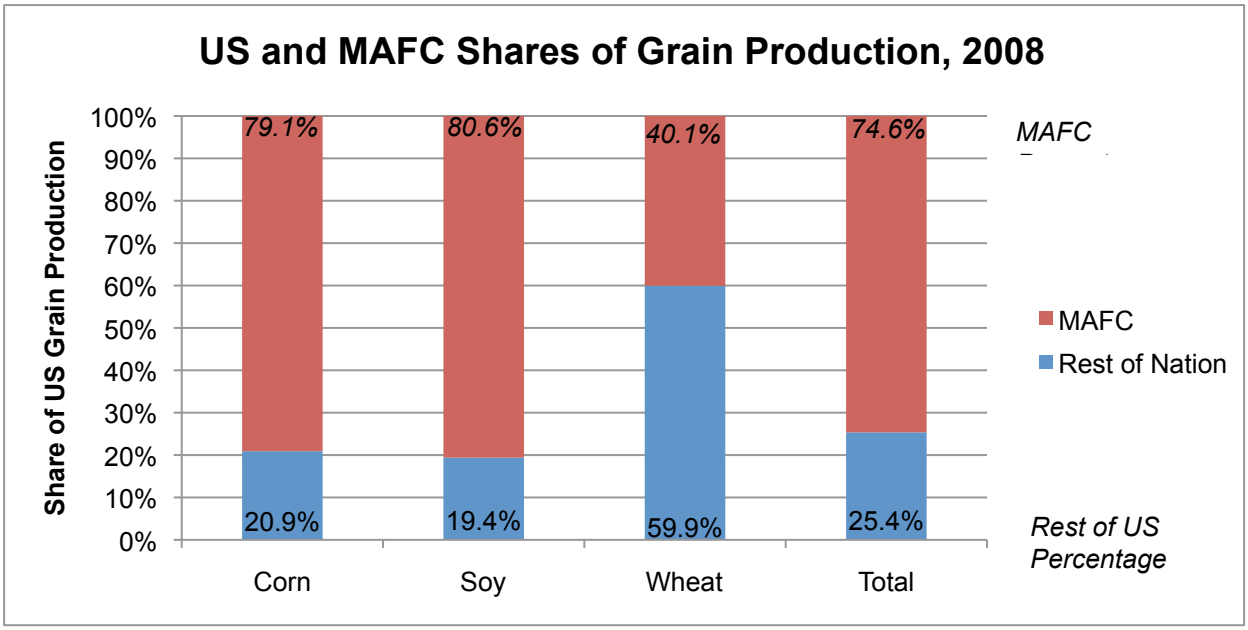

Figure 4: US and MAFC Shares of Grain Production

Current Domestic Grain Movements

Interstate grain movements are evaluated based on the FHWA 2002 Freight Analysis Framework (FAF).[6] Although the FHWA has released a 2008 supplemental dataset, the sample size was considered too small for use in this analysis.

Of all grain shipments originating within the MAFC region (including grain not bound for export), 33 percent was shipped to Louisiana, the single greatest receiver of grain shipped from MAFC states. The next greatest recipients, California and Texas, received only 10 percent and 8 percent, respectively, of MAFC shipments. Oregon and Washington, two important states for grain exports, only received a combined total of 2.5 percent of MAFC grain.

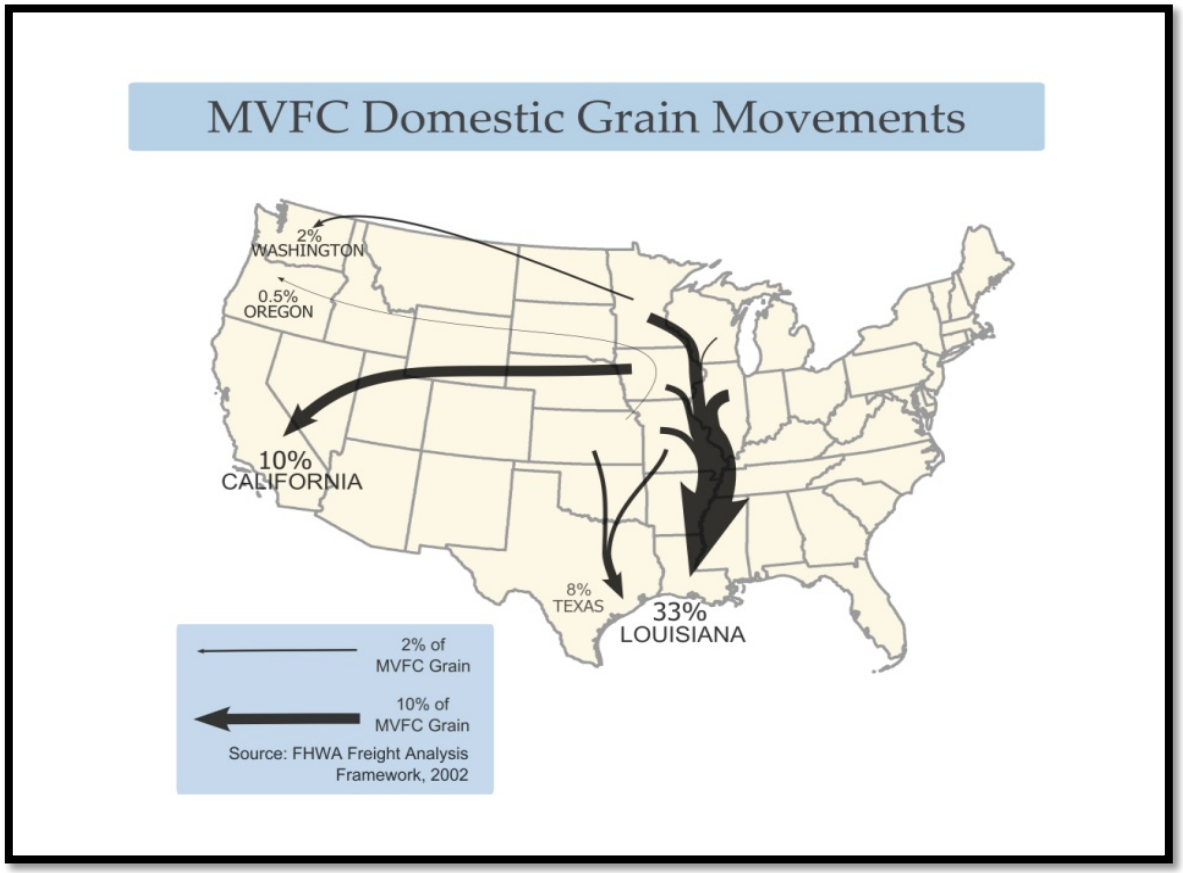

Figure 5: MAFC Domestic Grain Movements

Top Grain Ports

The 2002 FAF also sampled export activity. The data reveals that Louisiana ports accounted for 62 percent of grain exported overseas, by far the most of any state in the United States. Washington and Texas, the next-closest states, each moved only about 12 percent of exported grain, and Oregon and California shipped 7 percent and 6 percent, respectively.

The top exporting states receive grain from both the Midwest and other sources, with significant variation between states. For example, 95 percent of the grain that came into Louisiana and 87 percent of grain entering California originated in MAFC states. By contrast, Texas received 30 percent of its incoming grain from MAFC states, and Washington and Oregon, the next largest grain ports, received only 19 percent and 15 percent, respectively. When grain export figures are weighted by the grain's source, it becomes clear that Louisiana is a dominant player in the Midwest's grain export supply chain.

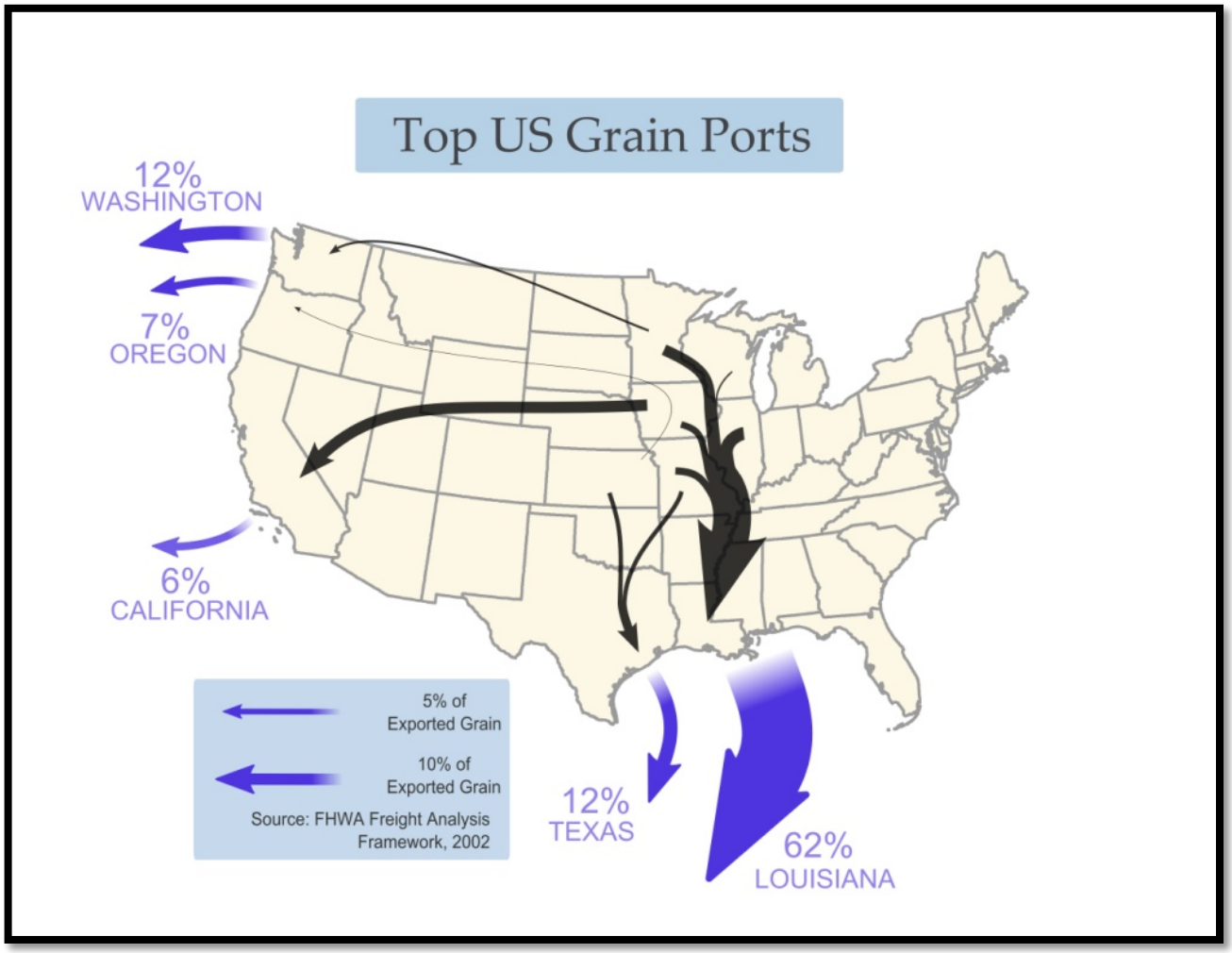

Figure 6: Grain flows to and from port states

Grain Destinations

US grain's most significant destination region is Asia, which consumed more than 40 percent of exported US grain. The next greatest consumers are South and Central America, consuming approximately 17 percent, and Mexico at 10 percent. Asian grain destinations are of particular relevance to the Panama Canal, where transits made as part of the US East and Gulf Coast to Asia route are by far the most significant source of Canal traffic.

Importantly, the export shares of US states varied somewhat depending on the grain destination. For instance, the share of grain exported to Asia was somewhat more balanced between Louisiana ports and West Coast ports. About a quarter of all grain exported from the United States left Louisiana destined for Asia, whereas around 17 percent was shipped from either Washington or Oregon, the two most significant West Coast port states for grain. In fact, virtually all of the grain shipped from Washington and Oregon ports was headed exclusively to Asian ports. Despite this, FAF records indicate that Louisiana ports easily remained the greatest point of origin for US grain shipped to Asia.

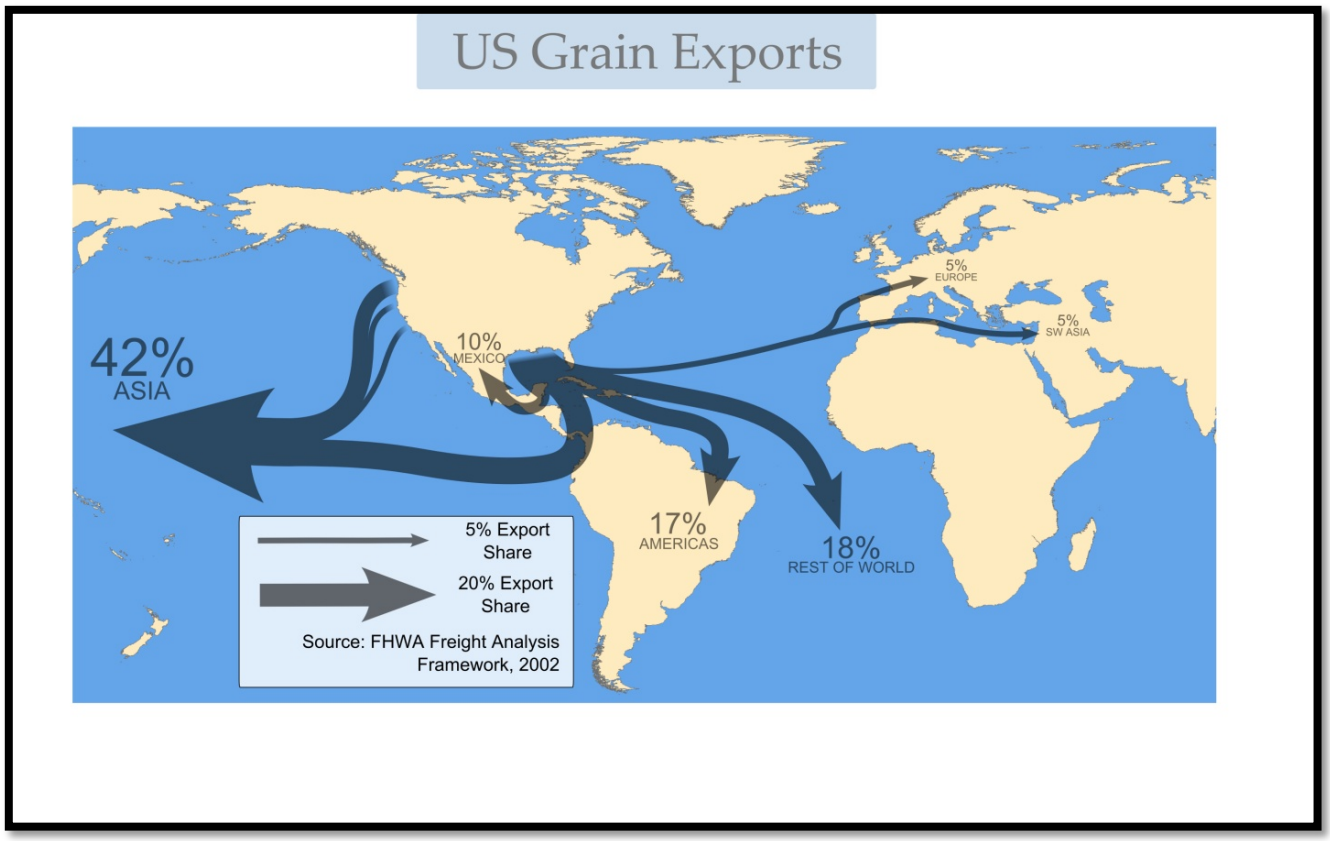

Figure 7: Destinations of US Grain Exports

Background

Based on the 2002 FAF data, Louisiana ports are the primary gateway for Midwestern exports on their way to Asian's growing market for grain. These shipments are almost certain to transit the Panama Canal and are the most vulnerable to market changes as a result of the expansion. However, one of the most important factors in assessing such changes—the Canal's new toll structure and levels—will not be known until the locks open, hampering efforts to quantify effects on trade patterns. However, this uncertainty has not prevented industry analysts and commentators from weighing in on the effects of the Canal's expanded capacity; the project team examined this body of literature—ranging from formal studies to informal speculation—to characterize current thinking on the expansion's effects.

These speculations have generally focused on consequences for trade and freight infrastructure in general, rather than the more particular case of grain exports. For example, in 2009 *The Economist* reported on the shipping industry's outlook for the canal expansion, quoting several experts who predicted long-term growth, or at least protection from "marginalization" as post-Panamax vessels become the norm in global shipping. However, one consultant predicted that the expansion would not have significant effects on non-containerized trades like bulk grains.[7]

The *Journal of Commerce* has also investigated East Coast preparations for a flood of new import activity and ultimately concluded that, while ports badly need the upgrades, the expansion will probably not bring a drastic change in shipping patterns.[8] Another *Journal of Commerce* report concluded that the shipping time and capacity advantages of the West Coast intermodal route means that a potential shift in market share "depends on how much cargo West Coast ports let slip away, rather than any gains in East and Gulf Coast efficiency." However, the article noted that the market for lower-value goods (such as grain) is "certainly up for grabs."[9]

There are three primary sources of information regarding the Panama Canal expansion's effect on US grain trade. These are:

- US grain associations
- The Panama Canal Authority
- Federal reports from the USDA, the Army Corps of Engineers, and other agencies

Only a few publications, mostly from the grain associations, address the Panama Canal with respect to grain exclusively; most investigate other, broader consequences of the expansion and examine grain exports peripherally. Consequences for containerized trade—the canal's largest market segment—have also been emphasized in published analyses. In these cases, projections and assumptions are made for canal traffic or grain trade in general, from which the project team can only draw inferences.

US Grain Associations

Given the potential impact the canal expansion might have on export activity, trade groups have said relatively little about the issue. The US Grains Council (USGC) has dedicated the most attention to the issue. By some accounts, direct benefits to grain trade from the expansion are expected to be fairly modest. A 2006 USGC "Global Update" newsletter, released soon after Panamanians voted in favor of the expansion, relates the following from industry consultant Jay O'Neil:

> Panamax bulk-carrier vessels are still the largest size vessels that most destination grain ports can handle… The grain industry really hasn't had a problem with the canal's vessel size capabilities in the past, just its transit delays. This expansion project should reduce wait times at the canal. [10]

On the other hand, some see accommodation of post-Panamax vessels as a catalyst for the growth of containerized grain. A USGC "Grain News" publication released in 2007 (more than a year after the previous quotation) explains:

> Phil Thornton, value enhanced projects director for the Illinois Corn Marketing Board, said as of mid-November, shipping via containers to Southeast Asia cost about $22 per metric ton less than bulk—although that differential can vary depending on current markets. Thornton said containerized shipping of grain and related products continues expanding after gaining in popularity over the last decade. "This sector will change dramatically again once the Panama Canal expansion is completed in 2014," he said. "That will allow larger container ships to move through the canal to the Mississippi Gulf. We could see significant increases in containers moving up and down the Mississippi River via barges at that time." [11]

The growth in demand for specialty grains and agricultural products is also a driver of demand for containerized grain shipping. According to Bruce Abbe of the Midwest Shippers Association, intermodal containers are "ideal for shipping identity preserved grains and oilseeds [such as] food grade, non-GMO soybeans for tofu," which are higher-value products than many other agricultural commodities. However, he notes that growth of this trade is restricted by container availability and rail and intermodal transportation service quality.[12]

Several other USGC articles make mention of the expansion, but beyond these publications there is very little commentary on the potential impacts. Most of the Council's attention is focused on overall trade patterns and areas of growth.

For example, Adel Yusupov, director of USGC's market development programs in Southeast Asia, wrote in 2009 that demand for meat in Southeast Asia has grown substantially. This in turn has prompted tremendous growth in demand for feed, even during the recent economic downturn. Mr. Yusupov concludes, "I see continuing growth in Southeast Asia's livestock production and feed demand amid commercialization of livestock farms and integration of feedmilling and trading companies."[13] He echoes many of the same sentiments in a contemporary report about a new containerized shipping service to Vietnam.[14]

Likewise, in the 2007 Corn Refiner's Association Annual Report entitled *Corn: Part of a Global Economy*, industry analyst Sakharam K. Patil writes:

> In [Asia, Eastern Europe and South America], food as well as industrial products will be important growth markets for refined corn products. Asia will be the largest growth area due to its sheer population size.[15]

These trends and predictions point to a growing demand for American grain across the Pacific, and the potential for increasing amounts of grain to flow from Gulf Coast ports through the Canal on its way to Asia.

Panama Canal Authority (ACP)

The ACP has produced several documents relating to the expansion, and the most important of these is the expansion proposal itself. In it, ACP identifies dry bulk (including grains) as an important market segment for the Canal. Until the rise of container shipping, in fact, dry bulk was the Canal's top revenue generator. Although dry bulk shipping is expected to continue growing, the expansion is unlikely to bolster its share of the Canal's tonnage, as the growth of containerized freight continues to outpace other shipping modes. The ACP projects that completion of the expansion will lead to an annual increase of 5.6 percent in containerized tonnage transiting the Canal, whereas dry bulk is expected to increase by only 1 percent during the same period. Looking outside the dry bulk sector to the Canal's overall performance, ACP estimates that the third set of

locks will increase Canal capacity by 1.25 billion tons over its first 11 years of operation, yielding a 12 percent internal rate of return.[16]

Under its no-expansion scenario, ACP estimated that the Canal will reach maximum operating capacity sometime between 2009 and 2012, and growth in grain shipping (especially containerized grain) would likely have to be diverted to other routes, particularly the Canal's chief competitor for the US East and Gulf Coast to Asia route: the US intermodal system and West Coast ports. Based on the same analysis under the expansion scenario, the Canal market share in the Northeast Asia–US East Coast route, an important pathway for grain exports, rises to 49 percent by 2025, as opposed to dropping to 23 percent under the no-expansion scenario.[16]

Federal Reports

Several different federal agencies have their eye on canal expansion. The US Army Corps of Engineers is responsible for regulating and reporting on the nation's various water-based ports. In a 2007 Upper Mississippi River System report, the Corps re-evaluated current plans for the region and, in part, addressed the potential effects of canal expansion. Most notably, Corps analysts assumed a $1/ton decrease in overall shipping costs for Midwest grain to Pacific ports. In addition, Canal expansion is a key factor in its 'High Traffic' scenario.[17]

The report also states:

> The expansion, expected to be completed before 2020, will reduce ocean freight costs and as a result likely draw more freight in and out of the country through the Gulf, including a substantial increase in containerized traffic. Distribution of containerized freight will require some level of barge utilization both upbound to markets and downbound either as empties or filled with goods destined for foreign markets. In addition, the all-water routings through the Gulf ports and up the Mississippi River with their inherently lower cost should be favorably competitive with routings through the U.S./Mexican/Canadian coastal ports that require a lengthy rail segment to reach interior markets.[17]

The report continues by predicting that this will place greater strain on rail and highway networks around Gulf ports, further pushing lower-value commodities (such as grain) into water-based alternatives. On the other hand, the Army Corps of Engineers cautions that the future of both the grain and shipping markets is filled with uncertainty. Factors such as domestic corn ethanol production, soy production in South America, and changes in the US rail system may all introduce substantial variation in export activity.[17]

The USDA also considers shipping as it relates to the movement of agricultural products. A feature article from a 2008 USDA *Grain Transportation Report* headlined "Grain Is the Principal U.S. Commodity Transiting the Panama Canal" hints at increased competition between Canal and US intermodal travel:

> The reduction in the amount of grain passing through the canal en route to Asia may be connected to the high ocean rates and spreads witnessed throughout the year. Because of these higher rates, more grains were shipped through the Pacific Northwest ports to Asia, especially wheat and soybeans. The impact of higher ocean spreads is more pronounced in the Gulf since a larger proportion of shipments out of East Coast to Asia originate from the Gulf ports.[18]

In January 2010, the USDA's Agricultural Marketing Service published a report, *Impact of Panama Canal Expansion on the US Intermodal System*, specifically comparing the two routes, although it does not pay particular attention to agricultural exports. It echoes other analyses in pointing to labor and congestion problems in West Coast ports as challenges for the intermodal route, and states that expansion of this infrastructure may be constrained by the need to "compete with community and environmental land uses for land on which to expand." It concluded that, for

shippers, the expansion may improve the attractiveness of the US intermodal route by reducing congestion in ports like Los Angeles/Long Beach, but suggests that long-run competitiveness with the Panama Canal requires new investments and fixes for existing bottlenecks.[19]

In April 2010, the USDA also published *Study of Rural Transportation Issues*, a report on a variety of important transportation issues facing the nation. An entire chapter is dedicated to ocean freight shipping, parts of which discuss the Canal expansion. The report pits the Canal against the land-based US intermodal system, discussing potential changes in the context of the relative advantages of each network:

> The major advantage of the U.S. Intermodal System is the opportunity to develop economies of scale in the transpacific maritime route. This route frequently uses Post-Panamax container ships, so only five ships are needed for a weekly service rotation instead of the eight ships required by the Panama Canal route. However, the port and railroad reliabilities have been affected by labor problems (strikes and shortage of labor to handle new cargo) and capacity expansion challenges such as congestion, as well as community and environmental land uses. As trade increases, many of the top ten U.S. container ports are reaching the limits of existing capacity.[20]

The Congressional Research Service (CRS) produced a report on Louisiana ports in the wake of Hurricane Katrina that highlights the importance of Gulf ports in the exporting of grain. In it, the CRS establishes the importance of the state's seaports, which rank among the busiest in the world, and cites earlier statements by the North American Export Grain Association that Louisiana's top ports "serve as a gateway for nearly 55-70 percent of all US exported corn, soy, and wheat."[21]

Along with these sources of uncertainty, new policy programs may also have significant effects. The Obama administration's National Export Initiative, which aims to double US exports by 2015, could result in additional strain on freight transportation systems if even partially successful.[22] However, it is too early to accurately predict the effects (if any) of the Initiative, which was announced in February 2010 and is still in its early stages.

Expert Insight

During the course of the study, experts in the field were contacted for guidance and to hear their views on the Canal expansion. Our contacts included managers of ports, shippers, and industry associations; academics; and USDA researchers. They consistently emphasized the uncertainty surrounding the Canal expansion—the possibility for structural changes in grain shipping depends largely on an unclear post-expansion toll structure and future economic conditions which are naturally uncertain.

The decisions on where to ship grain are rooted in the economics of grain shipping. Thus, to the extent that shipping grain via Gulf ports remains the most profitable route, Gulf ports may continue to dominate in grain exports. There are countless factors that contribute to this process: rail shipping rates, port capacity constraints, the cost of fuel, and destination port handling abilities, among others.[23]

Grain backhauls—shipments of grain transported as secondary cargo in order to facilitate moving ships and/or containers back to ports from which they move a primary cargo—are a factor in this equation as well. Many experts expect that the Canal expansion will lead to increased import activity at the ports and major demand centers of the East coast, possibly creating opportunities for lower-value exports like grain to be shipped as backhaul cargos. In fact, many ports are gearing up for this with port facilities expansions and channel deepening. With an influx in ships dropping off imported goods, shippers will be looking to fill that space for the trip back to Asia with exports. According to some observers, this will probably not pull grain from the West coast ports, but it could certainly keep grain from shifting westward. Most of this expanded shipping activity will be container-based, so the extra export capacity would probably affect containerized grain more than

dry bulk.[24] According to one industry analyst, container rates must generally be at least $10-15 cheaper than bulk to be considered for grain shipping.[25]

The experts and related literature all seem to agree on at least one point: transit times through the Canal should be improved after the expansion, with significant benefits to grain exporters, including reduced losses, faster delivery, and better opportunities for identity preserved products.

Industry Survey

In addition to consulting with experts, the authors contacted 81 Midwestern agricultural commodity companies involved in exporting wheat, corn, soy, and other grains with a survey on their expectations of how the Canal expansion might affect their business. The survey asked 13 questions relating to the respondents' current export business and transportation decisions, expectations regarding the Canal expansion and its impacts on factors such as prices and transit times, and planned responses to the expansion. Respondents had the option of completing the survey through web survey software, via email, or on paper.

Of eight respondents, five provided complete answers to the survey; the other three answered with only cursory statements on their export activities. Given the survey's low response rate, meaningful quantitative analysis of these results is impossible, but the answers and reasoning seen in them nevertheless corroborate several trends and predictions noted by experts and trade data.

Of the five respondents who answered the full survey, four listed Asia or China as their only major export destination, reflecting the large proportion of Midwestern grain exported to Asian destinations. Three relied on exports for a majority of their business (70 percent or more), while exports constituted only a small portion of sales for the other two (10 percent or less). The firms used a variety of modal options—including rail, trucks, barges, and combinations thereof—to move grain from elevators to seaports on the Gulf, Mid-Atlantic, and West Coasts. Despite differences in modes, four of the five respondents shipped their grain via container, rather than in bulk.

Expectations regarding the Panama Canal varied in some respects, but, like the aforementioned experts, a majority agreed that the expansion would decrease transit times across the Canal. For example, one import-export company stated that when "the Panama Canal is expanded, we would hope we could receive our shipments more quickly" from Chile to their Gulf and Mid-Atlantic ports. Three firms also expected that the expansion would encourage the use of Post-Panamax vessels in shipping grain, while none predicted the opposite. None of the firms expected the expansion to influence the incentives to use containerized or bulk shipping methods, and one noted that the decision was "dependent on steamship services and container supply" more than the Canal's capacity.

Although there was no consensus on the question of how the expansion would impact tolls or costs, all the companies indicated that they would at least "consider using different shipping routes or modes" to move their grain exports when the expansion was complete, although only two firms had already taken it into consideration in their logistics planning. One indicated that they expected to move more grain using barges, presumably down the Mississippi to Louisiana or other Gulf Coast ports.

Research Team Canal Tour

In order to gain a firsthand view of the Panama Canal's operations, the progress of the expansion project, and the area's trade activities, members of the research team visited Panama in April 2010. While in Panama, Jason Bittner and Robert Gollnik spoke with members of the Panama Canal Authority about their projections for agricultural freight and the completion of the expansion project. They also toured the Canal, the Manzanillo International Terminal in Colon, the Panama Canal Railway Company's freight line, and the Colon Free Trade Zone.

The team met with members of the Canal Authority responsible for grain shipments, marketing, and the administration of the expansion program. A focus of these meetings was the ACP's projections for agricultural shipments in the wake of the expansion. Because grain constitutes a significant portion of canal traffic, the Authority has paid considerable attention to this market segment.

ACP personnel, including Maria Sanchez, an expert on grain shipments, and Rodolfo Sabonge, vice president of market research, told the team that they expected to see growth in grain in the wake of the expansion, but noted that upstream limitations on grain volumes were a likely near-term issue. They noted, for example, that capacity and maintenance issues in the US inland waterway system could impede the flow of grain down the Mississippi River system to Louisiana ports. Another concern was the capabilities of origin and destination ports to accommodate post-Panamax containerships and bulk carriers. If East Asian and Gulf Coast ports, for example, cannot load and unload the large vessels the new locks can hold, grain shippers and carriers will not realize some advantages of the expanded canal. However, North American grain is not the only agricultural commodity relevant to the Canal's operations. Brazilian soybean exports to East Asia are also expected to experience substantial growth after the opening of the expanded canal.

Outside the agricultural export market, Sabonge noted that a major objective of the Canal expansion is to capture more market share of East Asian imports to the United States. However, whether these exports reach Gulf Coast or East Coast ports is a secondary concern for the canal. US grain exporters, on the other hand, have an interest in seeing greater vessel, container, and equipment availability at Gulf Coast ports.

ACP personnel were confident that the project would be completed on time and within budget. They stressed that the completion of the project is vital to Panama's future success as a trade hub and emphasized its importance to the nation's people. Visiting the canal and the third set of locks, Bittner noted "seeing this engineering marvel up close, you can see how the canal's overdesign has allowed it to function efficiently for nearly a century and remain a vital piece of Panama's economy going forward."

Touring the Manzanillo International Terminal (MIT), located just off the Atlantic entrance to the Panama Canal, the team was able to view the operations of one of Central America's largest transshipment terminals. MIT handles a high volume of containerized freight, consisting primarily of consumer goods but also including a small quantity of containerized grain. Bittner and Gollnik both gave a favorable assessment of the facility's scale and efficiency. The team also toured the Colon Free Trade Zone, an important procurement and distribution center for South and Central American retailers and the world's second largest free trade zone. They also toured the Panama Canal Railway Company. Visiting these operations underscored the vitality and diversity of Panama's transshipment, commerce, and logistics operations.

Energy and Emissions Analysis

While the primary interest of exporters and carriers in the Canal's expansion is the way its additional capacity can improve times and decrease costs, the energy costs and greenhouse gas emissions associated with exporting grain have serious environmental, economic, and geopolitical consequences.[26] Based on the comparatively low energy intensiveness of seaborne freight transportation, the Panama Canal expansion's potential to increase bulk and container shipping of Midwestern grain from Gulf ports led the researchers to hypothesize that the project would increase energy efficiency and reduce greenhouse gas emissions.

The majority of export journeys are taken by large bulk and container cargo vessels, which boast substantially lower fuel consumption rates on a per ton-mile basis than their counterparts on rails, roads, and domestic waterways. In order to quantify the effects of moves to intermodal routes with longer seaborne legs, such as via Gulf Coast rather than West Coast ports, the authors estimated existing and potential future emissions and energy consumption of all Midwestern agricultural exports across both domestic and maritime freight modes.

Domestic Freight

Because Midwestern agricultural products exported to overseas destinations must first move to an international port, nearly all such grains are destined for Gulf and West Coast ports, which (as discussed above) are primarily located in California, Louisiana, Oregon, Texas, and Washington. The impacts of these movements are a function of modal ton-miles from each origin-destination pair and emission and energy consumption factors of each mode. For single-mode domestic shipments, energy consumption is given by

$$EC^{m}_{o,d} = T^{m}_{o,d} * D^{m}_{o,d} * N^{m} * W_{d}$$

where $EC^{m}_{o,d}$ is the annual amount of energy (in Btu) consumed by mode *m* moving grain between origin-destination pair *o,d*; $T^{m}_{o,d}$ is the mode's grain tonnage moving between origin and destination; $D^{m}_{o,d}$ is the distance in miles between origin and destination via the shortest route on mode *m*'s network; N^{m} is the mode's energy consumption per ton-mile; and W_{d} is the proportion of all grain in the destination state that is exported overseas. Similarly, greenhouse gas emissions are given by

$$DE^{m}_{o,d} = T^{m}_{o,d} * D^{m}_{o,d} * M^{m} * W_{d}$$

where $DE^{m}_{o,d}$ is the amount of CO_2 emitted by each mode and origin-destination pair, and M^{m} is the mode's emissions in grams per ton-mile. Summation across modes and origin-destination pairs yields total domestic energy consumption from transportation of Midwestern grains for overseas export. The special case of intermodal and unknown mode categories, where relevant, is approached by using average values of all other modes shipping between the origin and destination states for consumption and emissions per ton mile and route distance.

Because FHWA freight movement information is aggregated at the state level, no single clear origin location is available. In order to approximate this point, geospatial analysis software was used to locate a weighted center of production for each state based on USDA county level production data. Destinations were based on each destination state's top port (as determined by annual volume). Routes and route lengths from each origin to each destination were then determined using network-based spatial analysis across rail and inland waterway systems, while highway routes were determined using web-based routing software.

Energy consumption factors are based on estimated 2002 figures from the Center for Transportation Analysis at Oak Ridge National Laboratory. These figures, combined with fuel emission estimates from the US EPA's 2010 Greenhouse Gas Inventory Report, yield emission factors.

Based on these calculations, the authors estimate that transportation of Midwestern grain to exporting states consumes $1.62*10^{13}$ Btu, with $1.36*10^{12}$ Btu from trucks, $3.16*10^{12}$ Btu from rail, $1.01*10^{13}$ Btu from domestic waterways, and $1.61*10^{12}$ Btu from intermodal and unspecified modes. Emissions from these movements are estimated to total 1.31 million tons: 109,815 tons of CO_2 from trucks, 255,167 tons from rail, 814,625 tons from domestic waterways, and 129,669 tons from intermodal and unspecified modes.

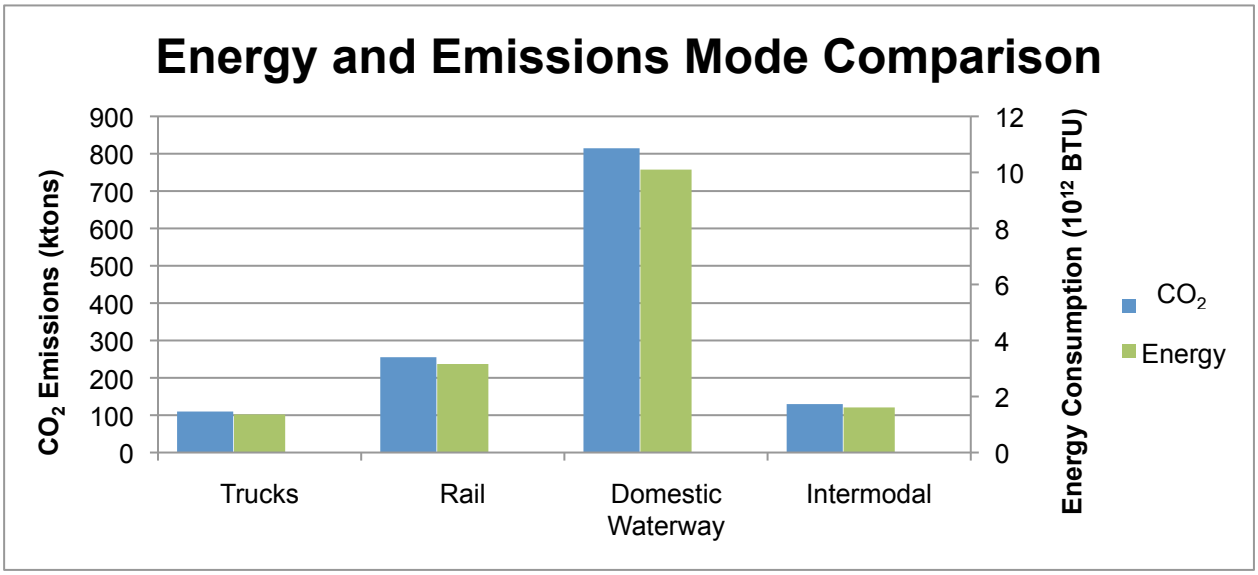

Figure 8: Energy and Emissions by Transportation Mode

	Btu/ton-mile [27]	Export Ton-Miles (billions)	Energy (trillion Btu)	CO_2 Emissions (ktons) [28]
Trucks	1546	0.87	1.36	109.8
Rail	345	9.84	3.16	255.2
Domestic Waterways	470	24.28	10.10	814.6
Intermodal & Other	954-1017*	1.58	1.61	129.7
Total	**N/A**	**36.57**	**16.24**	**1,309.2**

* Calculation based on average of applicable modes; varies by origin-destination state pair.

Maritime Freight

Like domestic grain movements, maritime freight movement of grains results in greenhouse gas emissions and energy consumption. However, large bulk and containerships are highly energy-efficient compared to domestic modes, with an estimated fuel consumption rate of just 130 Btu/ton-mile (85.2kJ/km). Energy consumption and emissions were estimated using the same formulas as the domestic modes. Since the FAF provides only the world region to which commodities are exported, not specific nations or ports, distances between US ports and destinations were

estimated by averaging the distances, generated by the online route-finding utility on searates.com, to top ports at approximately equally-spaced points along the coasts of the destination region.[29] For example, routes to Southeast Asia were approximated using an average of the distances between Hong Kong, China; Inchon, South Korea; and Bangkok, Thailand, and each US port.

Maritime freight vessels moved Midwestern grain 180.7 billion ton-miles to overseas destinations in 2002, consumed an estimated 27 trillion Btu (28.6 PJ)—approximately equivalent to the annual energy consumption of Costa Rica—and emitted 5310 ktons of CO_2.

Effects of Route Shifts on Energy Consumption

Because the Gulf Coast route represents the substitution of high-efficiency maritime miles for more energy intensive domestic miles compared to the West Coast route, the authors expected to find evidence that the Gulf Coast-Panama Canal route provides a lower-impact alternative. However, a comparison of the energy costs per ton of grain shipped supports the opposite conclusion: that the US Intermodal-West Coast route accounts for less energy consumed per ton than the Gulf Coast-Panama Canal route.

Because Gulf Coast and West Coast ports ship to different sets of destinations, a direct comparison of all grain exports is less informative than a specific case, such as exports to Southeast Asia. This market was chosen because of its expected growth in the near future and because Midwestern grain leaving from Louisiana and Texas is all but guaranteed to pass through the Panama Canal on its way to the region.[13] In large part because the maritime route through the Canal is roughly 75 percent longer than its West Coast counterpart, the Gulf Coast-Southeast Asia route consumes approximately 0.35MMbtu (369MJ) more energy, or an additional 23 percent, per ton of grain shipped. If, for example, Gulf Coast ports were to gain an additional 1 percent share of the total Midwest-Southeast Asia grain trade, the resulting change in energy consumption would amount to an additional $3.68*10^{10}$ Btu (38.8TJ) annually.

Economic Projections

Export Demand

In 2009, the USDA published a set of long-term projections for agricultural production and trade stretching to 2019. The authors of the report caution that it presents a particular scenario, not a "forecast about the future," but it provides a useful starting point for discussion of the economic context of the agricultural exports market. The report assumes steady recovery from the global recession, growing global demand for food and agricultural exports, slowing global population growth, a depreciating US dollar, increasing petroleum prices, continuity in federal agricultural and trade policy, growing demand for both biofuels and livestock, and "historically high" crop prices.[30]

Growing incomes and populations in the developing world are "the main source of growth in world demand" for agricultural exports. African and Middle Eastern markets are likely to see substantial growth in demand and "are projected to account for 50 percent of the increase in world wheat imports [and] 40 percent of the growth in rice and coarse grain imports" over the next decade. And according to the University of Wisconsin-Madison's most recent *Status of Wisconsin Agriculture* report, demand for specialized commodities like dried distiller's grains (DDGs) is expected to rise in Southeast and East Asia.[31]

Increasing demand for agricultural exports is complimented by an anticipated adjustment in currency valuations. As *Status of Wisconsin Agriculture* puts it, the combination of "a weak dollar and buoyant Asian economies" will likely strengthen American exports. Adjustment of the Chinese Yuan towards a higher and more accurate valuation would also improve the business climate for exporters.

In light of these conditions, the USDA projects stable planting acreages for major crops (between 246 and 248 million acres), with stronger production of corn in comparison to soy and wheat. Corn exports are projected to grow in absolute terms "in response to stronger global demand for feed grains to support growth in meat production," but will decline in terms of its share of the global market. Wheat exporters, on the other hand, are projected to experience declining market share and flat export volumes. Prices for corn are expected to "remain historically high" while wheat prices are expected to be stable. Other agricultural commodities, such as soy, rice, cotton, and horticultural crops, are expected to see substantial growth in exports.

A notable source of uncertainty in these predictions is the future role of biofuels in the United States. Use of corn and other commodities as feedstock for biofuel production competes with demand for exports and livestock feed.[32] The USDA reports that ethanol and other biofuels' "share in the overall gasoline market is relatively small, but its importance to the corn market is comparatively large," with approximately 34 percent of the 2009 US crop directed towards ethanol production.[1,33] However, projected future growth in biofuel production is heavily based on continued subsidization of the industry through tariffs and tax credits—45 cents-per-gallon for ethanol and $1.00-per-gallon for biodiesel producers. These tax credits face an uncertain future as debate continues over the environmental and economic costs and benefits of biofuels, and the degree to which their production should be subsidized.

West Coast vs. Gulf Coast Ports: Advantages and Challenges

Perhaps the most significant advantage of the Asia-West Coast route for grain exporters is that of distance, and therefore time. As reported by the USDA, the "US Intermodal System has the shortest ocean navigation time […] from Asia to the East Coast of about 18.3 days," while the Panama Canal route averages 21.6 days.[34] Our survey results indicated that the related factors of distance and time are serious concerns for exporters, and in an October 2010 panel on the impacts of the Canal expansion on the Port of Long Beach, Dr. Mary Brooks echoed this sentiment and

emphasized the increasing importance of "time-based competition." Brooks also noted that trends favoring slow steaming would adversely affect all-water routes to the Gulf and East Coasts more heavily than the West Coast-intermodal option.[35]

Another advantage held by West Coast ports is their present capability to accommodate very large bulk vessels and containerships. While major East and Gulf Coast ports are moving to raise bridges, dredge channels, and expand facilities in anticipation of the need to handle larger vessels and volumes of cargo transiting the expanded Panama Canal, West Coast ports have been unconstrained by the old Panamax standard and have less pressing needs for expansion projects.

However, West Coast labor disputes over the past decade—such as the highly visible 2002 lockout, which closed California, Oregon, and Washington ports for 10 days at an estimated cost in the billions of dollars—remain an obstacle to the competitiveness of the West Coast. The 2002 shutdown was followed by a one-day walkout in 2008 and similar threats in 2004 and 2007; as recently as the summer of 2010, strained union-employer relations in the ports of Los Angeles and Long Beach have led to speculation regarding shutdowns.[36] These actions by "more aggressive and militant West Coast unions" lend a comparative advantage to East and Gulf Coast ports in both reliability and labor costs.[37]

Dr. Jaffee notes that many carriers and shippers of Asian imports have migrated towards East and Gulf Coast ports, finding destinations like the Ports of Savannah and Jacksonville to have more favorable and stable labor environments. He cites the weaker position of union workers at the Port of Jacksonville as central to the decision of terminal operator Hanjin to locate a heavily automated facility there, and suggests that more employer-friendly labor laws and weaker unions make Eastern ports attractive destinations for imports.[37] Domestic exporters of agricultural commodities face similar incentives to reduce costs and transit times and increase reliability.

Another complication for West Coast ports is the challenge of new environmental regulations affecting ports, such as restrictions on idling and burning dirty fuels near shore. While certain ports such as Long Beach ("The Green Port") and Seattle ("The Green Gateway") have embraced sustainability and environmental protection goals as central to their operations—or at least for marketing purposes—, compliance with pollution control and other regulations nevertheless involves certain costs. As the Long Beach and Los Angeles Clean Air Action Plan states, "the ports voluntarily committed to a course of action that would come to represent a massive investment in environmental programs" in order to reduce their air quality impacts and maintain community support for needed expansions to their operations.[38] The cost of the program to the ports, state and federal regulatory agencies, and industry over its first four years (2006-2009) exceeded $900 million, and over $400 million is budgeted towards its initiatives for 2010-2014.[39]

It should be noted, however, that these programs might show long-term economic benefits for ports and carriers alike. Cost-benefit assessments of cold ironing, a notable pollution reduction strategy, have shown positive returns in many regions (depending on the relative costs of marine distillate fuel and electricity from the grid). One such assessment has determined that hundreds of thousands to over a million dollars in energy costs may be saved per berth per year by switching from conventional power to cold ironing systems.[40,41] And environmental investments in general may prove advantageous in the long term if increasingly stringent environmental regulations become more widespread in Southern and Eastern states or at the federal level. Michael Vanderbeck, Strategic Planning Manager for the Port of Long Beach, predicts that "the US will catch up to California," offsetting short-term losses with a longer-term competitive advantage.[42]

Domestic Mode Trends

Of the various modes by which Midwestern grain reaches Gulf and West Coast ports, inland waterways and rail together move the vast majority of exports. Although the 2002 FAF does not track the domestic origins of exported commodities, assuming that the modal proportions of

Midwestern grain entering a port state are the same as that of Midwestern grains shipped overseas indicates that 64.4 percent of grain arrives via inland waterways and a further 26.4 percent by rail—together accounting for over 90 percent of all grain exported from the MAFC states. Although using these modes frequently entails shipping grain some distance via truck at one or both ends of the rail or barge journey, their dominance in transporting grain long distances from the Midwest to port states makes them the primary focus of this investigation of modal trends.

Transportation of grains by barge on domestic waterways (principally the Mississippi and its tributaries) is a cost-effective alternative to rail and trucking, but the system of locks and dams that make it possible is aging and deteriorating. As of 2009, the American Society of Civil Engineers reported that 122 of the nation's operating inland locks are "more than 60 years old […] well past their planned design life of 50 years." Nearly half are classified as functionally obsolete.[43] For example, almost all of the 27 locks and dams on the upper Mississippi were built in the 1930s and are approaching 80 years in service.[44]

While the system is badly in need of reinvestment, waterway stakeholders have consistently claimed that both the funding mechanism and project approval and completion process for upgrading this infrastructure is not up to the task. The Inland Waterways Users Board, a federal advisory committee, has noted that "enormous project cost overruns and delays in project schedules have greatly strained the Inland Waterways Trust Fund balance," and has repeatedly criticized the US Maritime Administration, Army Corps of Engineers, and Congress for what it characterizes as costly and inefficient review processes and protracted construction times.[45]

Because of the severity of the situation, the barge industry has recently backed proposals to increase the barge fuel tax that currently supports the trust fund by 30-45 percent.[46] The industry has emphasized, however, that simply increasing the Trust Fund's revenue stream will not solve the infrastructure problem. The Inland Waterways Users Board has cautioned, "raising more revenue is not the answer, unless it is coupled with dramatic process change at all levels of government." The scale of waterway improvements needed is on the scale of billions, while funding available is measured in the tens or hundreds of millions.[45]

The aging domestic waterway system that much of the Gulf Coast's grain exports travel through has the potential to cause significant disruptions to the agricultural supply chain. Whether these disruptions take the form of unreliable locks and dams or higher taxes and construction-related delays, the condition of the waterways that carry almost two thirds of exported grain are a significant cause for concern, and may lead exporters currently routing grain down the Mississippi to the Gulf Coast to move their product to other modes—and perhaps other ports.

Domestic railways move nearly all grain shipped from West Coast ports, as well as a large proportion of grain exported from Texas. Its dominance in markets inaccessible to domestic waterways can be attributed to a variety of historical, geographic, and economic factors; for many producers and exporters, it "is the only cost-effective mode of transportation available."[47] The industry has also dramatically increased its efficiency and cost-effectiveness over the past three decades in the wake of deregulation, notably accomplished by the Staggers Act in 1980. Real rates for rail transportation have fallen by approximately 38 percent since 1981, while productivity—in terms of GDP generated per hour worked, and ton-miles of freight per track mile—has risen sharply in both absolute terms and relative to other modes. [48,49,50]

However, cutting underperforming and unprofitable track miles from the nation's rail network have accomplished much of this growth while traffic elsewhere has increased. Increasing profits by concentrating more traffic onto a smaller network cannot continue indefinitely, especially in light of US DOT projections that freight rail volumes will grow by as much as 88 percent between 2007 and 2035.[51] Accordingly, commentators have raised concerns that increasing freight volumes will outpace investment, leading to rail congestion and decreased reliability. Although railroads have invested a large portion of their revenue in new and upgraded infrastructure in recent decades, the

USDA has nevertheless warned that a "shortfall of investment could threaten the United States' competitive position as a low-cost supplier of high quality grain."[47]

One report, prepared by Cambridge Systematics for the Association of American Railroads, has compared current levels of service (LOS) of "primary rail freight corridors" with projected future LOS with and without investment in new capacity. Presently, 88 percent of rail miles are operating well below capacity (LOS A, B, or C), compared to 12 percent that carry traffic near, at, or exceeding their capacity (LOS D, E, or F). 2035 projections indicate that, without improvements, only 45 percent of mileage will be operating well below capacity, while 55 percent will be near, at, or above capacity—an overload that "would affect nearly every region of the country and would likely shut down the national rail network." In an alternative scenario, a slate of new and expanded infrastructure would increase the proportion of LOS A, B, and C rail miles to 97 percent, but this investment is estimated to cost $148 billion over 28 years. To fully fund this expansion, Class I railroads would need to nearly double their rate of capital investment.[51]

Another issue of concern for grain exporters is the availability of both intermodal containers and grain cars; shortages of either type of equipment can impede agricultural exports. As volumes of freight leaving the United States rise, demand for intermodal equipment has increased in areas like the Midwest that receive fewer containers from imports than they require for exports.[52] And shortages of grain cars have been discussed by both agricultural and railroad groups; though there is disagreement on the causes of and solutions to the problem, both shippers and carriers acknowledge that the seasonal nature of grain exports make it difficult to justify investment in sufficient grain cars to accommodate demand during peak times.[48, 53]

Predictions

With these data in mind, opening of the Panama Canal is predicted to have a number of short- and long-term impacts on shipping of agricultural commodities from the Midwest.

In the short term—the five-year period from 2015-2020 immediately following the opening of the canal—we do not expect to see increases in the sizes of ships carrying agricultural products through the Panama Canal. The primary impact for grain exports, rather, will be faster transit times through the Canal, as the new lane of traffic alleviates existing congestion issues. Because grain is a lower-value cargo compared to many other goods that transit the canal, shippers cannot generally justify paying for reserved transit times. Lower wait times will therefore be a significant windfall for agricultural exports.

In the same time frame, an intra-regional shift in production towards the Dakotas is anticipated to lead to more rail shipments to Pacific Northwest ports. Elsewhere on the West Coast, volumes of Midwestern grain leaving the ports of Los Angeles and Long Beach are anticipated to remain significant but experience lower rates of growth. In light of increasing domestic demand for ethanol feed stocks, corn is likely to constitute a decreasing share of agricultural exports in the future.

Containerization is anticipated to continue making headway in the grain export market, especially given China's increasing demand for specialty and identity preserved grains. Rising demand for meat will also lead to an expanded—and containerized—market for dried distiller's grains as a livestock feed. One caveat, however, is the current problem of container and intermodal equipment availability, which may put a temporary damper on the use of containers by agricultural exporters.

The share of grain exports that the Panama Canal will capture after the opening of the third set of locks is highly sensitive to the pricing scheme in place at that time. If reservation and toll structures increase the cost of the route too much, an increasing share of low value agricultural commodities will find other routes to market.

Conclusions

The opening of a third lock on the Panama Canal by 2014 will significantly change the capacity of the Canal for inter-ocean movements, affecting the decisions of Midwest grain and agricultural product exporters and improving the all-water routes that much of the region's exports are shipped through.

However, there is limited information available regarding market expectations once the expansion is completed, due to uncertainties in grain markets in general and the fact that toll prices will be subject to change up to the opening of the expanded Canal and beyond. As with any predictive analysis, great uncertainty exists in anticipating grain trade patterns driven by economic, environmental, political, and technical factors years into the future.

Insofar as a consensus exists, there appears to be agreement between experts, exporters, and government agencies that transit times for grain shipments will likely decrease. The Canal's ability to accommodate post-Panamax bulk and containerships may erase some of the advantages of the US intermodal system, providing increased incentives for the containerization of grain and improvement of Gulf and East Coast port facilities. Volumes of Midwestern grain leaving via California ports are expected to experience slower growth than shipments leaving from the Gulf Coast or Pacific Northwest.

In the long term, the Panama Canal's expanded capacity to transit more and larger vessels may give it a favorable position to take advantage of the expected growth in grain exports to Asia, but this is not necessarily meaningful to the short-term logistics decisions of exporters. Finally, despite the reduced energy intensiveness of maritime freight transportation, increased grain traffic through the Panama Canal may lead to higher energy consumption and greenhouse gas emissions.

Appendix: Technical Details of Panama Canal Expansion

Images in this section are courtesy of the Panama Canal Authority (ACP)

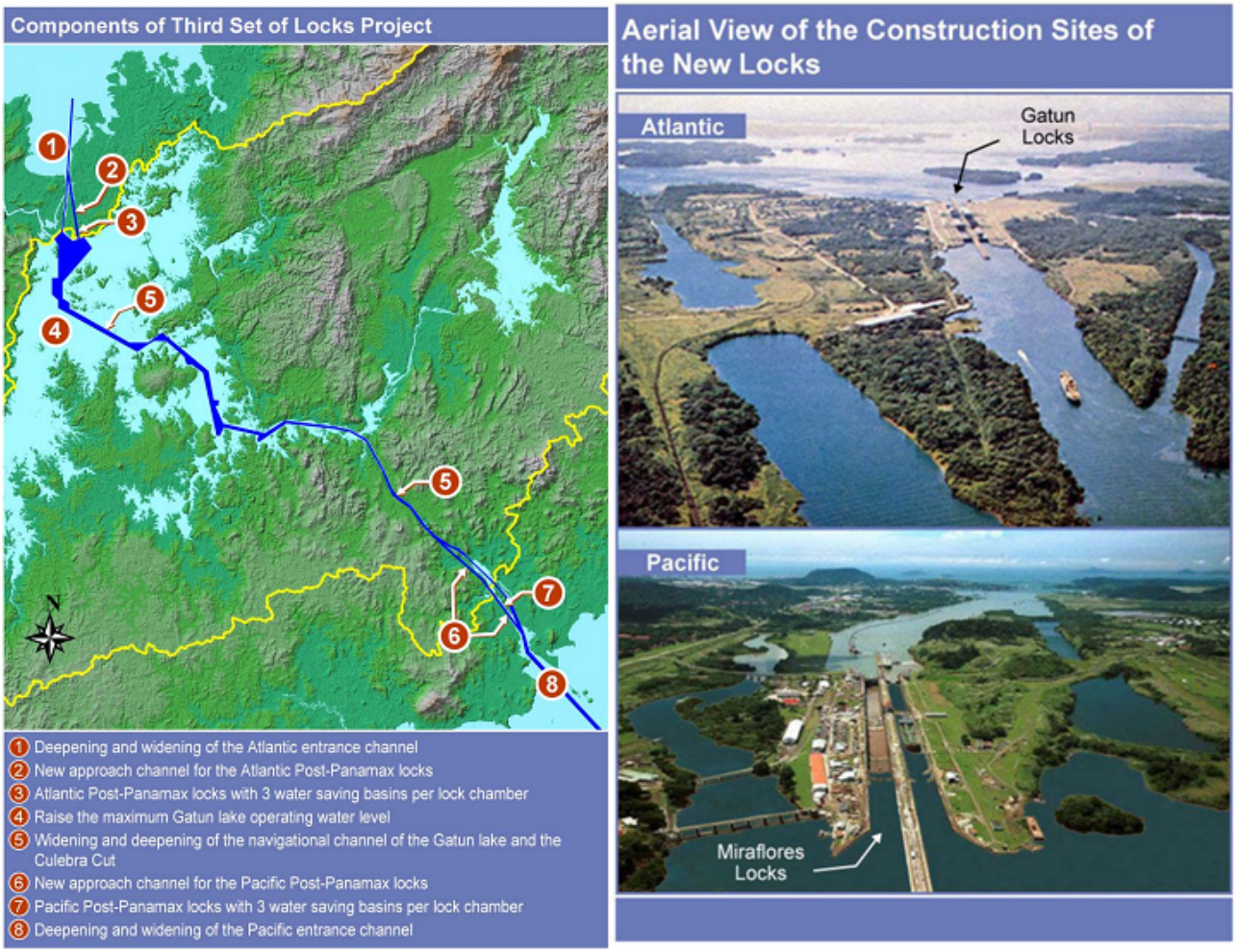

Figure 9: Expansion Components and Aerial View

The expansion of the Panama Canal consists of a third set of locks, as well as new and expanded navigation and access channels, and measures to elevate Gatun Lake's operating level. These projects will improve water availability, increase drafts, and allow post-Panamax vessels to navigate the Canal. As of August 2010, the Canal Authority had awarded $4.19 billion in contracts for construction out of an estimated $5.25 billion budget; these contracts included specific tasks including:[54]

- Excavation, construction, and dredging of the Pacific Access Channel
- Dredging to deepen and widen channels in Gatun Lake and the Culebra Cut
- Dredging of Gatun Lake and Atlantic access and entrance channels
- Raising the operating level of Gatun Lake by 45 centimeters
- Construction of water-saving basin systems in the third set of locks
- Design of the third set of locks

The $5.25 billion budget includes over $1 billion in funds set aside for contingencies, and the project is currently proceeding on schedule and under budget. In addition to the above

expenditures, the expansion project has created work for over 8,000 Panamanians; at the project's peak, approximately 12,000 jobs are expected to be tied to the expansion.

Third Set of Locks Specifications

Figure 10: Rendering of Third Set of Locks

The new post-Panamax locks under construction are the most prominent piece of the expansion project, accounting for over half of the project's budgeted costs. These locks will measure 427 meters long, 55 meters wide, and 18.3 meters deep, allowing for the transit of containerships with capacities of 12,000 TEUs or more, and bulk vessels of 150,000-170,000 tons.[2] Although these dimensions are insufficient to allow the largest containerships and tankers to pass through the Canal, they represent an increase in capacity of approximately 267 percent.

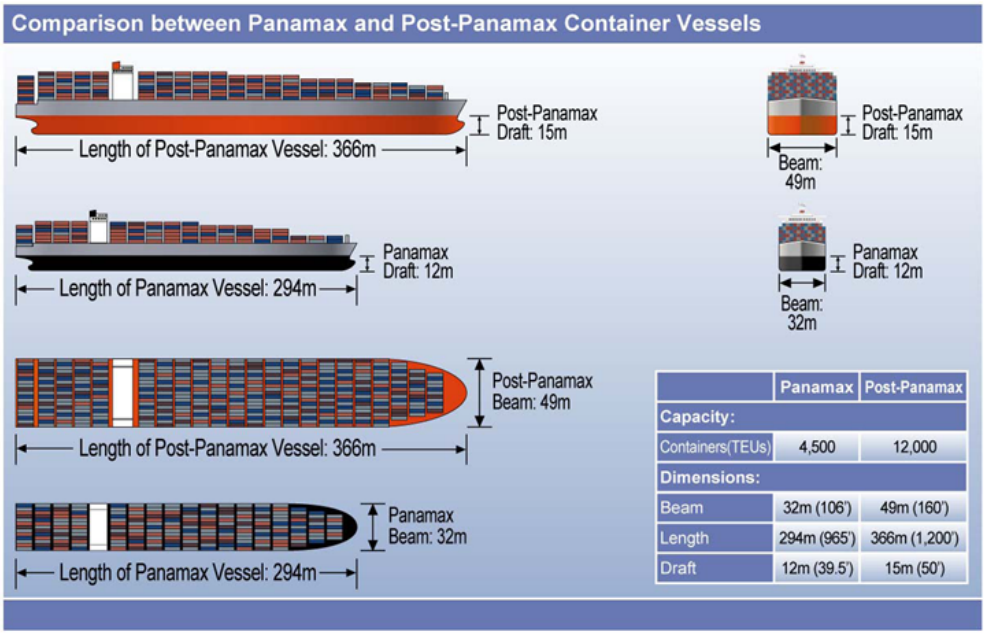

Figure 11: Comparison of Vessel Capacities

Courtesy of the Panama Canal Authority (ACP)

In addition to greatly increasing the Canal's capacity, the new locks present an opportunity to introduce new design features to the canal. These include a water-saving system of basins, intended to reduce the amount of water necessary to operate the locks and reduce the environmental impacts of the Canal's operations; the use of rolling gates instead of the miter gates used in the canal's other locks; and the use of tugboats instead of locomotives for vehicle positioning.

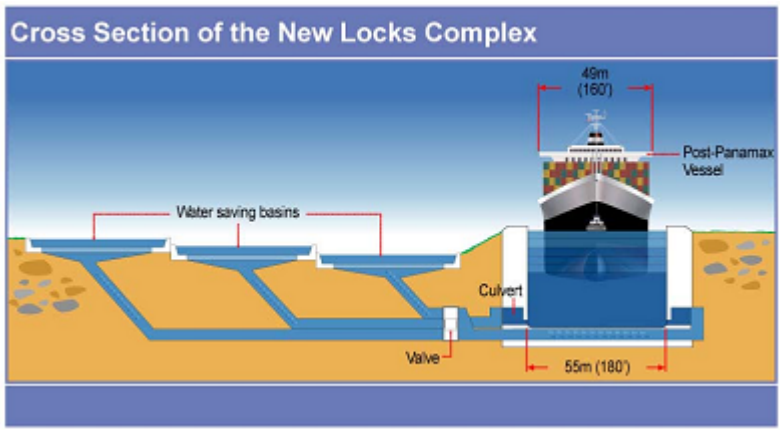

Figure 12: Water Saving Basins

In order to connect the new locks and allow ships with deeper drafts to navigate the canal, several new channels are under construction. A 3.2 kilometer channel connects the Atlantic-side locks to the canal entrance, while two channels (6.2 kilometers and 1.8 kilometers, respectively) connect the Pacific lock to the Gaillard Cut and the Pacific sea entrance. All channels "will be at least 218m (715') wide […] which will permit post-Panamax vessels to navigate in these channels in a single direction at any time."[2] Meanwhile, existing channels are being dredged to match the depth of the new navigation channels where necessary.

Finally, the elevation of Gatun Lake's "maximum operational level […] by approximately 0.45m (1.5') from the present 26.7m (87.5')" is intended to increase the daily supply of water for lock operations. The ACP anticipates that this change will allow "approximately 1,100 additional lockages without affecting the water supply for human use that is provided from Gatun and Alhajuela Lakes" each year.[2]

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