# THE RELATIONSHIP BETWEEN U.S. TRANSPORT INFRASTRUCTURE IMPROVEMENTS AND INTERNATIONAL TRADE

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## Abstract

In this study, the Freight Policy Transportation Institute (FPTI) at Washington State University (WSU) reviews the relationship between U.S. transportation infrastructure improvements and national trade competitiveness. The extent to which the condition of transport networks influences the integrity of local and global supply chains is central to understanding the impact of infrastructure investment policy decisions. According to U.S. Department of Commerce and Bureau of Transportation Statistics, during the last decade the international freight and port services trade increased by 69% and 103%, respectively. The U.S. agricultural trade that is more reliant on timely and efficient transportation has doubled during the same time period, with 114% increase in exports, and 103% increase in imports. In addition, according to the U.S. Department of Transportation, the volume of containerized cargo will double by 2020. A combination of recent trends and projected increases in transportation services demand suggest maintaining and investing in efficient transport infrastructure, a network system that serves as a main platform for the national trade and integrated supply chains. Implications for the U.S. export competitiveness are discussed in the context of the recent governmental national export competitiveness initiative.

## 1. Introduction

U.S. supply chain and export competitiveness is essentially dependent on the national transportation infrastructure. The complex system of seaports, airports, warehousing and distribution centers is connected through intermodal transportation networks to local and global markets. Maintaining efficient transport infrastructure that serves as a platform for integrated global supply chains is crucial for meeting the increased demand for transportation services. The influence of transportation infrastructure improvements on economic growth and development is one of the key questions in transport economics, which has been subjected to numerous reassessments (Aschauer, 1989; Clark et al., 2004; Easterly, 1993). Nevertheless, the general agreement in the peer-reviewed literature is that the transportation infrastructure improvements, combined with necessary political and institutional conditions can contribute to economic growth by facilitating international trade, strengthening regional supply chains, and creating jobs (Nadiri and Mamunes, 1994; Banister and Berechman, 2001; Istrate et al., 2010). In this study, the Freight Policy Transportation Institute (FPTI) at Washington State University (WSU) reviews the relationship between U.S. transportation infrastructure improvements and its export competitiveness.

Investigation of infrastructure investment effects on net welfare changes is particularly important to the U.S. in the aftermath of the recent economic recession. In particular, infrastructure improvements are essential for export competitiveness in agricultural commodities trade, an export-oriented industry that heavily relies on timely and efficient transportation of crops from production regions to processing and/or transshipment locations and exporting ports. Further, understanding the extent to which the improved transport infrastructure may contribute to the country's export competitiveness is particularly essential in light of the grain export-competitor countries' (e.g., Brazil) recent investments in new and efficient transportation capacity and infrastructure (Cost et al. 2007).

Increasing U.S. international trade has recently been prioritized by the National Export Initiative and National Supply Chain Infrastructure Competitiveness Initiative (U.S. Department of Commerce, 2010). As the recent Presidential executive order states "…a critical component of stimulating economic growth in the United States is ensuring that U.S. businesses can actively participate in international markets by increasing their exports of goods, services, and agricultural products. Improved export performance will, in turn, create good high-paying jobs" (The White House, 2010). The path to export growth critically depends on capacity improvement of the complex, interconnected transportation networks, which include highway networks, railroad, intermodal terminals, inland waterways and sea ports.

To better implement proposed export promotion plans at the state and national levels, policymakers need to understand how investments in different areas of the aging U.S. transportation infrastructure will contribute to the country's international trade flows and producer revenues through an overall increased economic activity. Increasing exports and staying highly competitive in world markets, requires maintaining reasonable transportation costs, which can be achieved by preserving and developing efficient transport infrastructure. To facilitate the decision making at the policy-level, the main goal of this study is to highlight the potential impact of infrastructural improvements in the U.S. transportation networks on the country's export competitiveness. Current issues of freight transportation, including waterways lock improvement projects, port-rail connectivity, volume and capacity are discussed to emphasize the need for improvements the national transportation infrastructure system.

The rest of the sections are organized as follows. Section 2 revisits the link between transportation infrastructure and economic growth by discussing approaches for measuring the impact from transport infrastructure investments, including a summary of estimates for output elasticity of public investments. It also reviews the recent literature investigating the impact and spillover effects of transportation infrastructure improvements on international trade. Section 3 discusses U.S. transportation services trend, including agricultural commodities trade trends and export shares of production for selected commodities. This section also discusses increased freight and port services, and modal share issues. Section 4 concludes by discussing the implications in the context of U.S. national export competitiveness initiative.

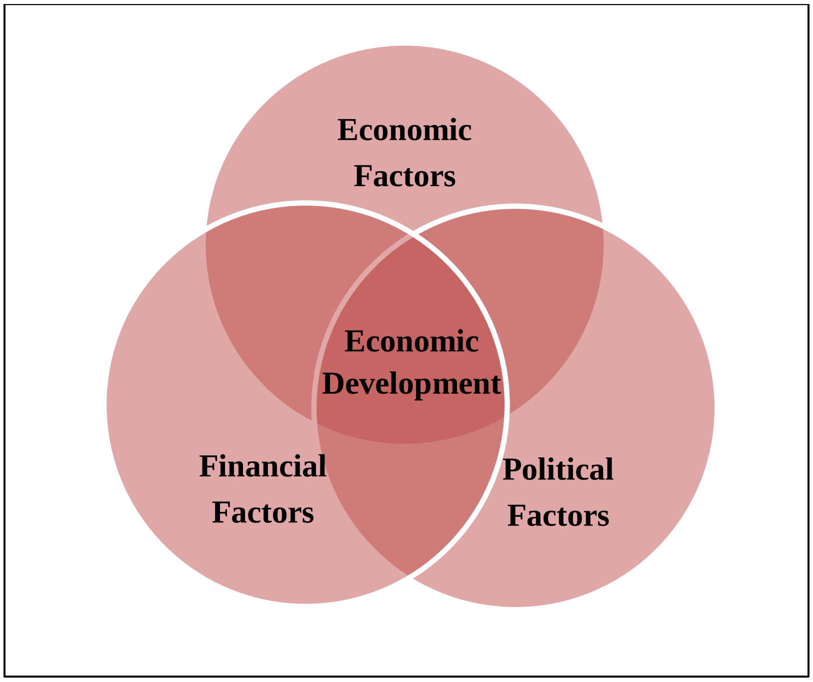
## 2. Transport Infrastructure and Economic Development

Transport infrastructure as an important determinant for countries' ability to compete in world markets has been widely discussed in the fields of regional and transport economics and international trade. However, certain conclusions about the relationship between transport infrastructure improvement and economic growth largely depend on the methodology used to evaluate the impacts. The impact from transportation infrastructure improvements can be measured by its direct benefits, such as travel time, congestion, accidents reduction, and additional benefits, such as long-run increased economic activity that leads to economic development. Whether transport infrastructure investments promote economic growth at both urban and regional levels is a subject to more detailed investigation about the micro vs. macro-level of cost and benefit analysis (Banister and Berechman, 2001).

### *2.1 Factors of Impact Assessment*

It is important to consider that in contrast to emerging and developing economies, the infrastructure investments in developed countries where the transport networks are of high quality will not contribute to economic growth if considered separately (Banister and Berechman, 2001). In other words, the transport infrastructure investments are necessary but not sufficient condition, rather they can complement other conditions that are necessary for economic development (e.g., location, implementation strategy and timing, highly skilled labor, regional and local dynamics, etc.).

**Figure 1:** Combined Effects of Economic, Financial and Political Factors




Source: Adapted from Banister and Berechman (2001).

Figure 1 combines 1) economic—dynamic local economies, skilled labor, 2) political—supportive policies, legal processes, and organizational framework, and 3) financial—location considerations, timing and scale of investment factors that collectively form a situation in which economic development is possible. Any combination of two factors will lead to a situation in which a one of the determinants of long-run economic development is missing.

In particular, the effects of only economic and financial/investment factors taken in isolation are short of supportive policies. Similarly, political and economic factors lack an important component—financial means (investments that are necessary for infrastructure improvements in our case). Finally, financial and political factors do not consider positive externalities, such as economies of agglomeration. Nevertheless, investment in transport infrastructure is still a fundamental component for economic growth to result.

A growing body of literature linked productivity growth to infrastructure provision developed after the appearance of a seminal paper by Aschauer (Aschauer, 1989). The positive relationship between economic growth and public infrastructure investment has been summarized in a survey article by Button (1998). Studies measuring the extent to which the infrastructure investment influenced the total factor productivity found a statistically significant between the two. Depending on the level of geographic aggregation, the output elasticity of public infrastructure investment may range between 0.03 and 0.39, indicating a 1% increase in public capital investment would lead to 0.03-0.39% increase in total factor productivity (Table 1). Although, these estimates do not exclusively refer to transportation investments, but the transportation infrastructure was the main component in each of these studies (Button, 1998).

**Table 1:** Estimates of Output Elasticity of Public Infrastructure Investments

| Author(s) | Geographic Scale | Output Elasticity of Public Investment |
|---|---|---|
| Aschauer (1989) | National | 0.39 |
| Holtz-Eakin (1994) | National | 0.39 |
| Munnell (1990) | National | 0.34 |
| Costa et al. (1987) | States | 0.20 |
| Eisner (1991) | States | 0.17 |
| Mera (1973) | Regional | 0.20 |
| Duffy-Deno and Eberts (1991) | Urban Areas | 0.08 |
| Eberts and Fogerty (1987) | Urban Areas | 0.03 |

Source: Adapted from Button (1998).

Despite the positive correlation between economic performance and the quality of infrastructure reported in numerous studies, the causality direction remains fairly ambiguous (Button, 1998). Additionally, the consideration of infrastructure scale and scope is critical for impact assessment studies (Winston, 1991).

### *2.2 Bilateral Trade and Spillover Effects*

The view of necessary but not sufficient conditions to measure economic growth has also been investigated within the framework of trade liberalization and investments in infrastructure (Bond, 2006). Distinguishing between spillovers from trade liberalization and technological advancements, this study investigated mutual incentives for trading countries to invest in their transport infrastructure. This adds another complexity to measuring infrastructure investment effects—spillover gains resulting from bilateral trade.

The quality dimension of infrastructure improvements, including road, airport, port, and time required for customs clearance is another important topic and has been investigated in Nordås and Piermartini (2004), with a bilateral trade flow gravity model. Three sets of gravity equations were estimated using clothing and automotive sector data, with variables focusing on infrastructure quality (pertaining to roads, ports, airports, telecommunication, and customs clearance time). The study found that (1) bilateral tariffs have a statistically significant negative relationship with bilateral trade flows, and (2) among all of the indicators tested in the model, port efficiency has the biggest influence on the bilateral trade flows. Meanwhile, timeliness and access to telecommunications were found to be positively correlated with export competitiveness. All of the above mentioned relationships support earlier comments the benefits of infrastructure improvements on long-run improved trade competitiveness.

Limao and Venables (2001) investigated the dependence of transport costs on transport infrastructure and found a statistically significant negative estimate of trade flows elasticity with respect to trade cost (the estimated elasticity was found to be around – 3) . Deteriorating transport infrastructure reduces trade volumes through supply disruptions and increased transport costs. For instance, the infrastructure deterioration from median to 75$^{th}$ percentile leads to a 12% increase in transport costs. This would consequently reduce the trade volumes by about 28%.

The relationship between infrastructure investment and the volume of trade can also be evaluated by including the length of country's motorway network in gravity models of trade (Bougheas et al., 1996). The results based on European data showed that there is generally a positive relationship between infrastructure investments, volume of trade and economic welfare.

### *2.3 Spatial Temporal Models for Impact Analysis*

Inferences about net welfare changes from micro-level transportation segment analysis may not be sufficient to generalize about the impact of infrastructure improvements. However, improvement investments are mostly implemented at micro-level projects that collectively form country-wide aggregate investments. Relationships between specific transport infrastructure links (e.g., inland waterways) and gains in producer revenues have widely been investigated within the framework of spatial, intertemporal equilibrium models (Fuller et al., 2000; Fuller et al., 2001; Fellin et al., 2001; Costa and Parr, 2007). Spatial equilibrium models were developed by Samuelson (1952), and found large use in empirical literature after Takayama and Judge (1964) further formulated Samuelson's approach into a quadratic programming problem. Current spatial equilibrium models of (agricultural grain) trade are developed based on these early formulations, which allow deriving optimum solution for regional prices, modal changes, and interregional trade flows. Spatial models of grain trade involve domestic and foreign excess supply and demand levels and intermodal transportation costs, which are used to derive prices and trade flows from a producer and consumer welfare maximization problem.

The impact of the transportation infrastructure improvement within the spatial intertemporal modeling framework is measured by comparing exports, prices and producer revenues from two simulated models. One of the simulations models serves as a benchmark based on initial transportation costs, i.e., *ex ante* infrastructure improvements. The follow-up model is simulated *ex post* improvements, with transport cost reduction. Resulting export levels, prices and producers revenues are compared from two models to measure the impact of the infrastructure improvements on export competitiveness.

Using a similar model, Fuller et al. (2001) evaluated the extent to which improvements in the specific transportation systems South American countries influence the corn and soybean trade with the United States. Increasing annual exports by 3 million (M) tons was found to be positively correlated with producer revenues of $1 billion (B)/yr. South American marketing and transportation network improvements resulted in projected declines in U.S. soybean and corn prices ($2.12 and $0.25/ton, respectively). Thus, the producer revenues from soybean and corn were projected to decline by $187 and $102M/year, respectively. While the relative impact on the U.S. exports was found to be modest (about 1.2 and 1.4%), South America's gain in exports was comparatively higher (8.4 and 2.3%). In turn, the gain in exports translates into South America's increased soybean and corn producer revenues ($4.95 and $8.72/ton) (S. Fuller, Y. Tun-Hsiang, Fellin, et al., 2001).

The U.S. export competitiveness in the world grain trade is also influenced by the levels of competitor countries' infrastructure investments. The effects of Brazil's transportation systems improvements on the world soybean trade have been investigated using computable general equilibrium modeling approach (Costa et al., 2007). With respect to the Brazilian soybean industry, not all of the sectors gained from the improved and decreased internal transportation costs in Brazil. For instance, soybean farmers gained in revenues, but the soybean crushing industry revenues declined as result of increased soybean prices. Nevertheless, under the 30% transport cost reduction simulation scenario, the infrastructure improvements led Brazil to become a primary soybean exporter in the world. As it pertains to U.S. export competitiveness, the study found that although insignificantly, but its export share declined due to infrastructure investments in Brazil.

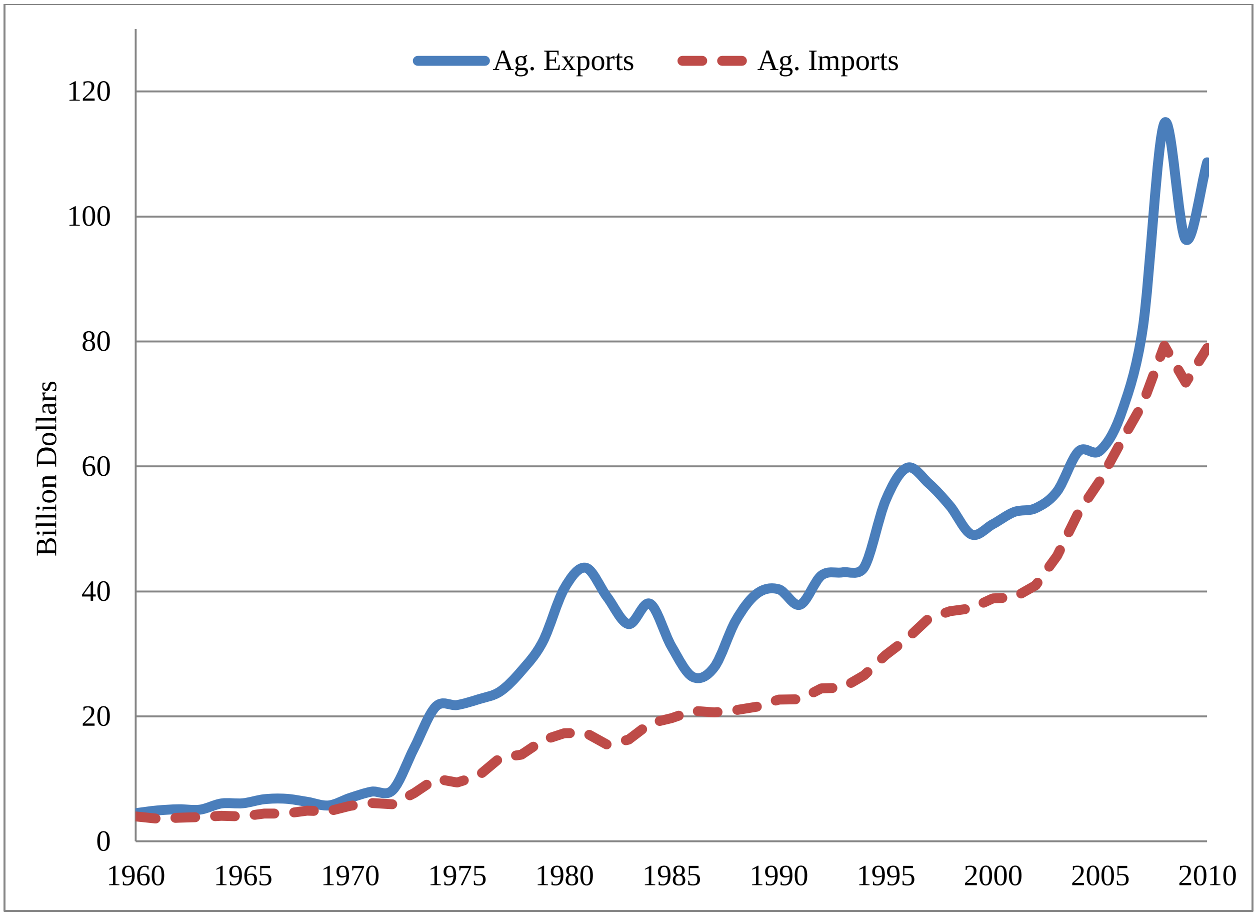
Similar conclusions were supported by the results found in Costa and Rosson (2007), utilizing international spatial intertemporal models of international grain trade. The gain in Brazil's soybean prices and thus, producer revenues were found to be relatively higher (relative to U.S. losses). Although, the improvements in all sectors of transport systems resulted in increased exports, prices and revenue, the waterways improvement provided the highest increase in prices and revenue. Therefore, it is important to isolate and compare the effects on export competitiveness resulting from various segments of the transportation infrastructure– e.g., highway system, railroads, waterways improvements and sea ports.

# 3. Transportation Demand Trends and Infrastructure Improvement Needs

## *3.1 Agricultural Commodities Trade*

The efficient and affordable freight transportation system that facilitates the linkage to international markets has always been important drivers for U.S. export-oriented. In turn, the importance of participating in international trade is reflected in increasing exports over the past decades (Figure 2). Despite the sharp decline of the 1980's and late 1990's, the value of agricultural exports has exceeded the imports since early 1970's. The sharpest decline in agricultural commodities exports happened during the economic downturn of 2008 – 2009, followed by a quick recovery in 2010. The positive trade balance since the 1970's lead to higher farm prices and increased producer revenues. Reasons for exports fluctuations include but are not limited to U.S. dollar's value against foreign currencies, changes in the economies of importing countries, and foreign countries' favorable agricultural policies leading to increased competition in the world export markets.

**Figure 2:** Value of U.S. Agricultural Trade




Data Source: USDA ERS (http://www.ers.usda.gov/data/fatus/)

The extent to which international markets are important to largely export-oriented agricultural economy can also be reflected in export market shares of major agricultural commodities shown in Table 2. The export share of total agricultural production has gradually increased from 15.9% in 1988 to 21.4% in 1996. Primary crops and meat and livestock categories' export share increased from 25.8% to 31.1% and 7.4% to 11.1% respectively. The average percentage of export market share is higher in the 1990s'indicating that U.S. farm income becomes more reliant on the foreign trade. In turn, foreign trade relies on cost-effective and timely transportation efficiency.

Table 3 shows the export shares for several important agricultural commodities. Excluding grapes, soybeans and sunflower seed categories, the export share of production for other major agricultural commodities was found to be increased from 1988 to 1996. Most notably, the export share for almonds increased from 51.6 to 71.8%, apples shares were 12%, up from 6.2%. Export shares of wheat and soybeans are significant, averaging about 51% and 34% respectively.

**Table 2:** Export Share of Production for Selected Agricultural Commodities and Totals

| Commodity | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Percent | | | | | |
| Primary crops | 25.8 | 27 | 28.4 | 31.9 | 27.2 | 28.7 | 26.4 | 30.4 | 31.1 | 28.5 |
| Meat & livestock | 7.4 | 8.6 | 8.6 | 8.1 | 7.6 | 9.2 | 9.2 | 9.6 | 11.3 | 8.8 |
| Total agriculture | 15.9 | 16.3 | 16.9 | 18.1 | 17.2 | 18.2 | 17.6 | 20.2 | 21.4 | 18.0 |

Data source: USDA ERS (http://www.ers.usda.gov/publications/agtrade/expshare.pdf)

With increasing world food demand and growing foreign per capita expenditures on U.S. farm products, the positive relationship between agricultural export shares and foreign market dependence has important implications for trade policies. In particular, the pattern in export share of production for agricultural commodities suggests adequate response in investing and increasing transport capacity is needed in order to support uninterrupted trade flow.

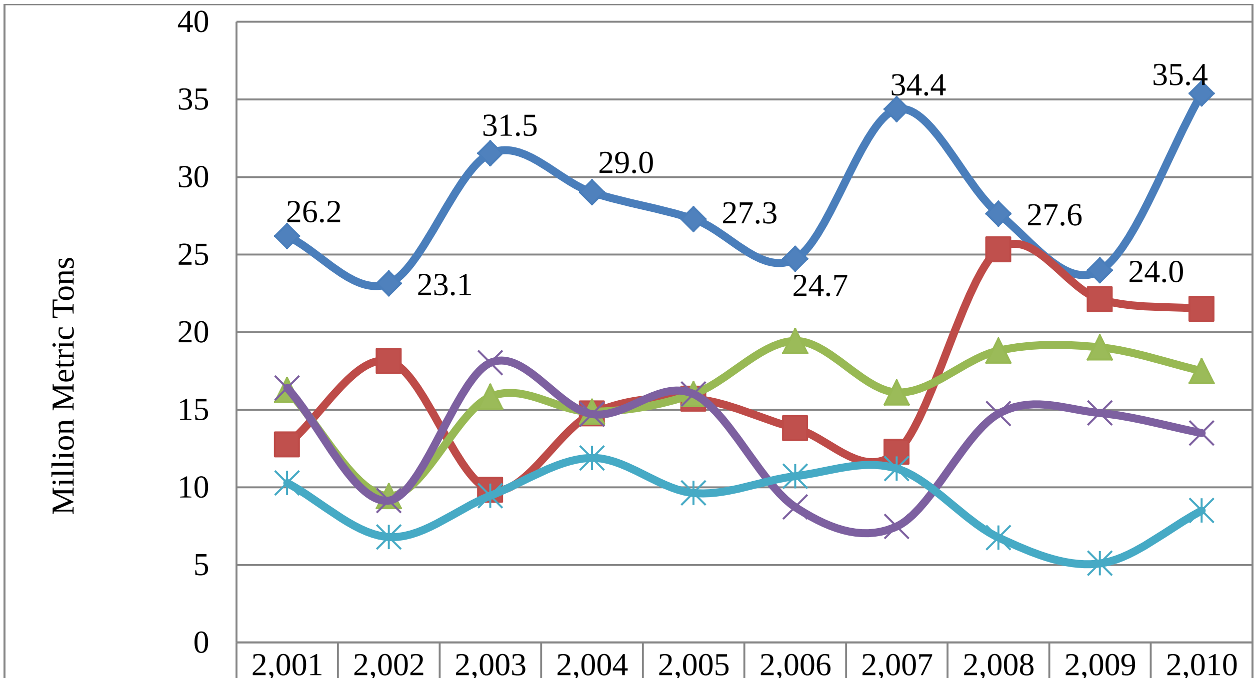
**Table 3:** Export Share of Production for U.S. Major Agricultural Commodities

| Commodity | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Percent | | | | | | | | | |
| Beef & veal | 2.1 | 3.4 | 3.5 | 3.7 | 4.3 | 4.1 | 4.9 | 5.1 | 5.4 | 4.1 |
| Poultry | 4.3 | 4.5 | 5.7 | 5.9 | 7.1 | 8.3 | 11.1 | 14.5 | 17 | 8.7 |
| Pork | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.2 |
| Oranges | 5 | 5 | 6.2 | 3.8 | 7 | 7.2 | 5.7 | 6.4 | 5.2 | 5.7 |
| Grapefruit | 5 | 5.4 | 6.7 | 10.6 | 10.7 | 9.2 | 8.5 | 8.5 | 9.1 | 8.2 |
| Apples | 6.2 | 6.2 | 8 | 8.5 | 12.1 | 10.3 | 13.8 | 12.9 | 12 | 10.0 |
| Grapes | 9.7 | 8.8 | 5.6 | 8.9 | 8.9 | 8.1 | 8.5 | 9 | 9.3 | 8.5 |
| Almonds | 51.6 | 57.3 | 66.2 | 71.7 | 71.6 | 80.8 | 67.7 | 81.8 | 97.1 | 71.8 |
| Corn | 22.3 | 27.5 | 29 | 22.6 | 20.3 | 19.4 | 17.1 | 24.6 | 24.4 | 23.0 |
| Wheat | 55.8 | 58.4 | 46.8 | 41.1 | 53.1 | 54.9 | 48.5 | 49.5 | 53.5 | 51.3 |
| Rice | 45.5 | 57.2 | 49 | 46.4 | 45.4 | 50.9 | 43.2 | 58.2 | 48.1 | 49.3 |
| Sorghum | 29.5 | 39.6 | 34.1 | 35 | 43.5 | 34.8 | 31.2 | 35.6 | 36.5 | 35.5 |
| Soybeans | 37.3 | 31 | 33.9 | 30.3 | 34.8 | 34.4 | 30.8 | 36.2 | 35.3 | 33.8 |
| Sunfl. seeds | 20.3 | 9.4 | 11.2 | 8.9 | 7.2 | 6 | 6.1 | 11.6 | 10.7 | 10.2 |
| Cotton | 45.5 | 47 | 47 | 44.5 | 42.2 | 33.9 | 41.7 | 44.3 | 42 | 43.1 |
| Tobacco | 14 | 15.3 | 18.9 | 17.8 | 17.1 | 14.5 | 14 | 15.1 | 14.1 | 15.6 |

Data Source: USDA ERS (http://www.ers.usda.gov/publications/agtrade/expshare.pdf)

Recent wheat trade data published by the Foreign Agricultural Service Production, Supply and Distribution (FAS PSD) shows that the U.S. wheat exports have dominated in the top 5 wheat exporting countries (Figure 3). Despite the significant reductions during the last three years, due to the economic downturn, the U.S. is leading exporter with more than 35 million metric tons exported in 2010, the highest. The rest of the major wheat exporting competitor countries listed in the FAS PSD online database are European Union, Canada, Australia, and Argentina.

**Figure 3:** Top 5 Wheat Exporting Countries by Volume

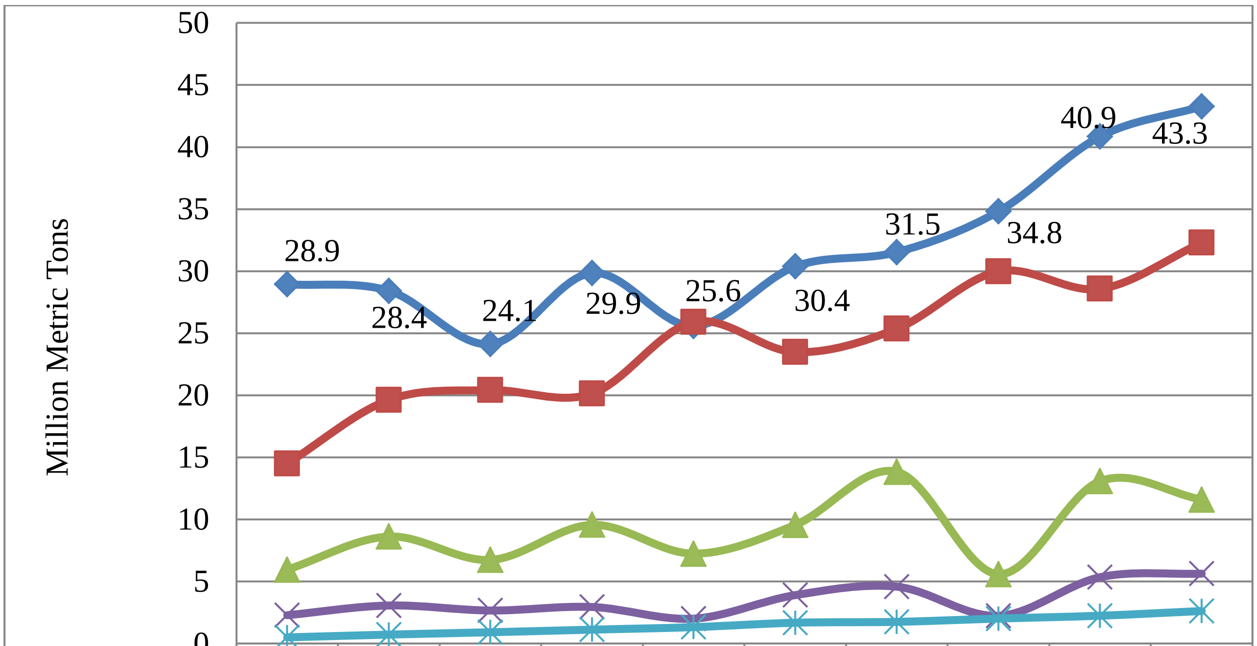



| | 2,001 | 2,002 | 2,003 | 2,004 | 2,005 | 2,006 | 2,007 | 2,008 | 2,009 | 2,010 |
|---|---|---|---|---|---|---|---|---|---|---|
| U.S. | 26.2 | 23.1 | 31.5 | 29.0 | 27.3 | 24.7 | 34.4 | 27.6 | 24.0 | 35.4 |
| EU-27 | 12.8 | 18.1 | 9.8 | 14.7 | 15.7 | 13.8 | 12.3 | 25.3 | 22.1 | 21.5 |
| Canada | 16.3 | 9.4 | 15.8 | 14.9 | 16.0 | 19.4 | 16.1 | 18.8 | 19.0 | 17.5 |
| Australia | 16.4 | 9.1 | 18.0 | 14.7 | 16.0 | 8.7 | 7.5 | 14.7 | 14.8 | 13.5 |
| Argentina | 10.3 | 6.8 | 9.5 | 11.9 | 9.6 | 10.7 | 11.2 | 6.8 | 5.1 | 8.5 |

Data Source: Foreign Agricultural Service. Production, Supply and Distribution Online Database. Website: http://www.fas.usda.gov/psdonline/psdHome.aspx

Soybean world exports are largely dominated by U.S. and Brazil, followed by Argentina, Paraguay, and Canada. The U.S. soybean exports increased almost 70% since 2005, reaching more than 43 million metric tons in 2010. Brazil, the second largest producer of soybeans has significantly increased the export levels during the last decade, reaching 32.3 metric million tons in 2010.[1]

**Figure 4:** Top 5 Soybean Exporting Countries by Volume




| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| U.S. | 28.9 | 28.4 | 24.1 | 29.9 | 25.6 | 30.4 | 31.5 | 34.8 | 40.9 | 43.3 |
| Brazil | 14.5 | 19.6 | 20.4 | 20.1 | 25.9 | 23.5 | 25.4 | 30.0 | 28.6 | 32.3 |
| Argentina | 6.0 | 8.6 | 6.7 | 9.6 | 7.2 | 9.6 | 13.8 | 5.6 | 13.1 | 11.6 |
| Paraguay | 2.3 | 3.1 | 2.7 | 3.0 | 2.0 | 3.9 | 4.6 | 2.2 | 5.4 | 5.6 |
| Canada | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.7 | 1.8 | 2.0 | 2.2 | 2.6 |

Data Source: Foreign Agricultural Service. Production, Supply and Distribution Online Database. Website: http://www.fas.usda.gov/psdonline/psdHome.aspx

[1] More details on U.S. export destinations for wheat, corn, soybeans and cotton is provided in the Table 4 of the Appendix.

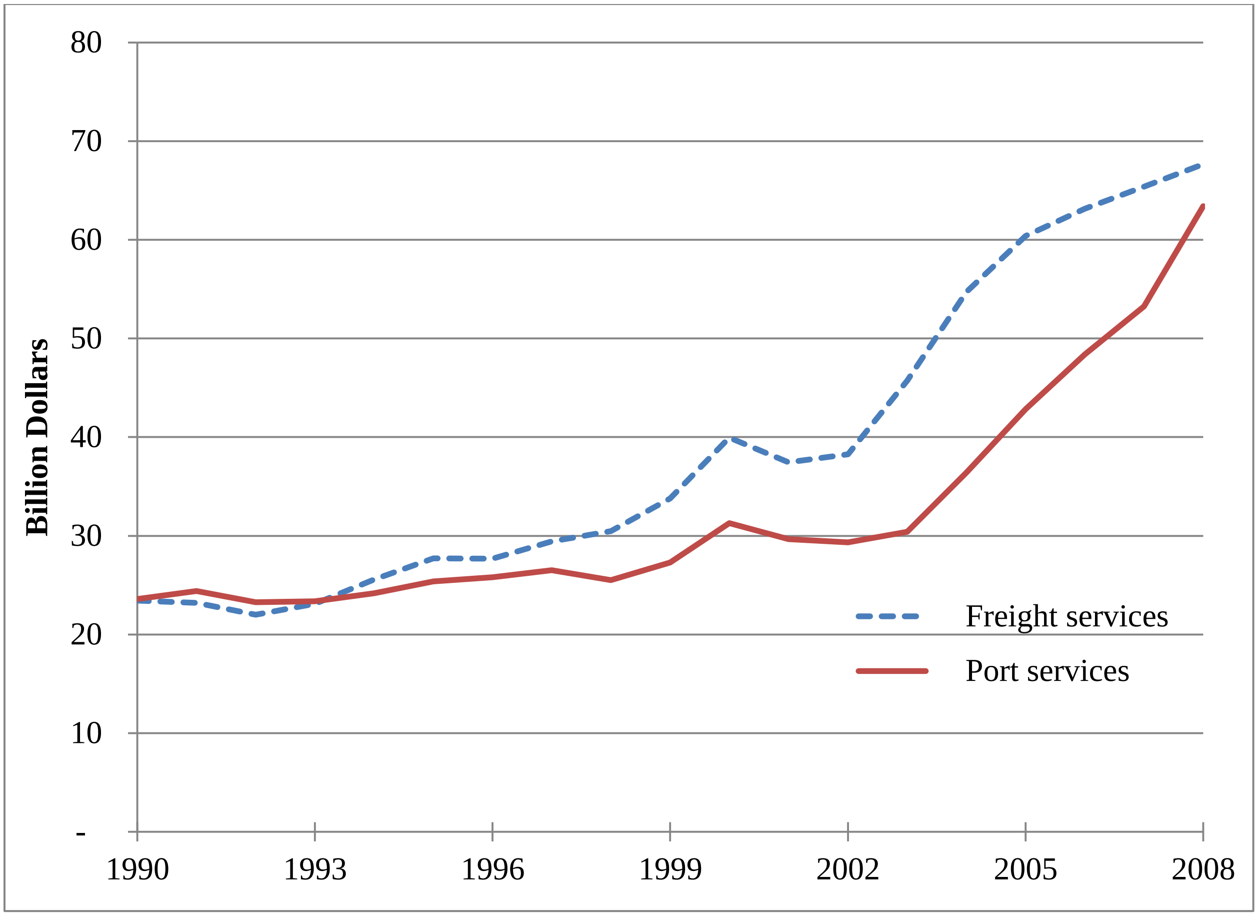
The trend in key agricultural commodity exports and imports, as well as export share of production for major commodities, speak about certain need for increasing transportation capacity and improving existing infrastructure.

### *3.2 Freight Services and Modal Share*

World's leading economies—U.S., Japan, China, Germany and France cumulatively account for 50% of global gross domestic product (GDP) of $60.9 trillion (TN) and 35% of global goods exports of $16 TN. With its most expensive freight transportation network measured by the length of paved roads, waterways, railroad, pipelines, and number of airports, the U.S. has the highest level of freight activity. Due to relatively larger geographic area and lower population density, goods are shipped comparatively longer destinations from producers to local end-user locations and export ports.

Although as a result of emerging economies, the U.S. share of world GDP has declined between 2001 and 2008 (after the "dot-com boom" years), the demand for its freight and port services has significantly increased (Figure 5). After relatively short steady state from 2000 to 2002, the U.S. freight services increased by 69%, reaching $68 B/year in 2008. Compatibly, since 2003, the port services doubled in value, reaching more than $63 B/year in 2008.
From 2007 to 2008, the total international merchandise trade and imports passed through U.S. freight system increased about 12% and 7%, respectively. This trend is consistent with the U.S. trade growth of about 7% per year since 1990. The combination of observed and projected increasing trade volumes encourage further development and/or maintenance of transportation facilities that link local producers to foreign markets.

**Figure 5:** U.S. International Freight and Port Services Trade

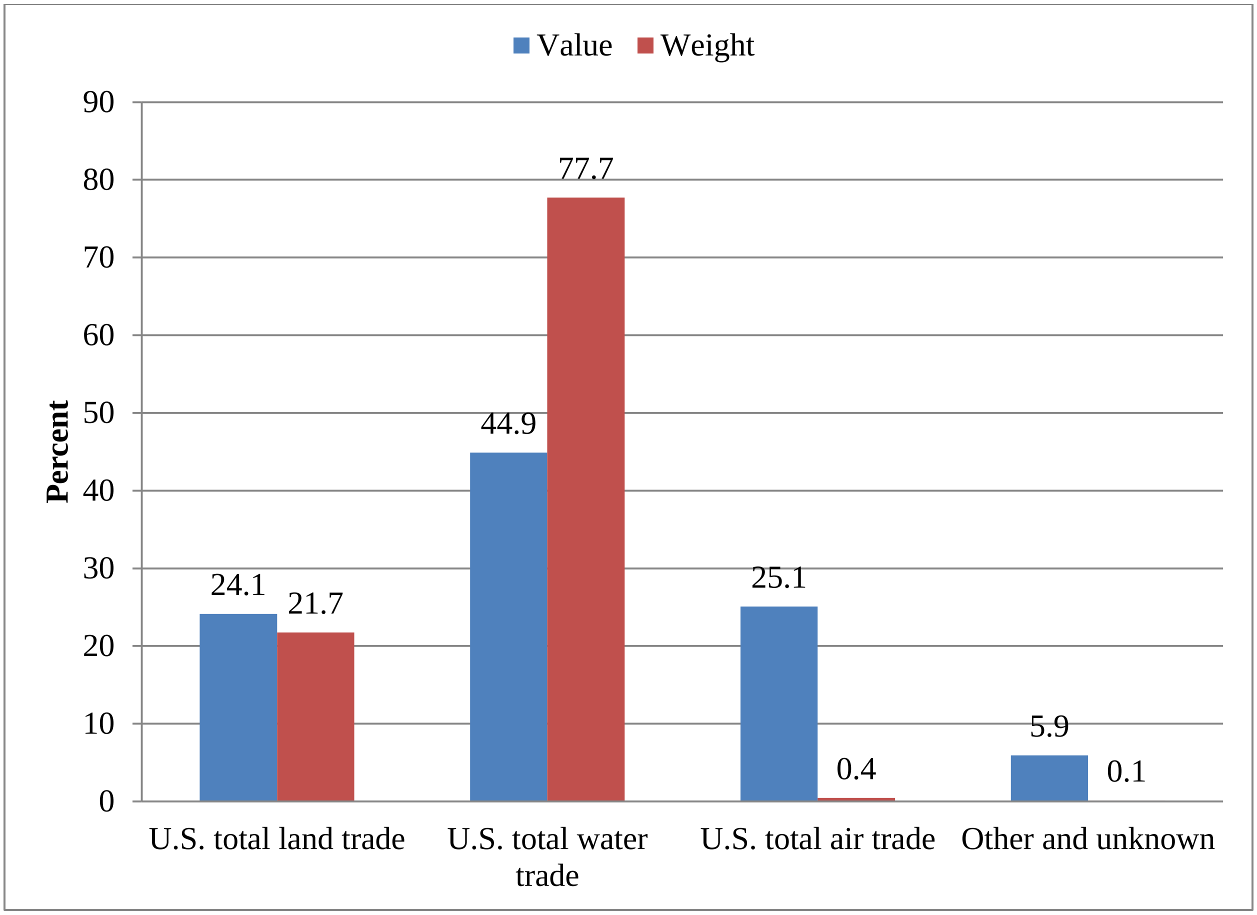



Data Source: Research and Innovative Technology Administration, Bureau of Transportation Statistics 2010, Freight Transportation: Global Highlights (http://www.bts.gov/publications/freight_transportation/)

The modal share utilization trend is another important consideration for prioritizing transportation infrastructure investments. Almost all of the freight transportation uses some combination of two or more modes of transportation: trucks, trains, barges, and ocean vessels. Depending on distance, a cargo of export goods may be transported from local production area to transshipment locations using trucks, then continue its way by rail or barge to exporting ports. Among other considerations, mode utilization depends on the industry (commodity type) and geographic location (accessibility). For example, rail (generally utilized for long-destination shipments) is the most cost-effective mode for many agricultural products transportation from elevator to transshipment location or exporting port shipments. Truck mode is utilized for shorter-distance, time-dependent shipments.

According to freight transportation statistics by the Bureau of Transportation Statistics, 77.7% (by weight) of U.S. merchandise trade uses waterborne transportation, and 21.7% relies on either truck or rail modes (Figure 6). Only less than 1% of the trade volume is attributed to air transportation.

**Figure 6:** Modal Share of U.S. Merchandise Trade




Data Source: Research and Innovative Technology Administration, Bureau of Transportation Statistics 2010, Freight Transportation: Global Highlights (http://www.bts.gov/publications/freight_transportation/)

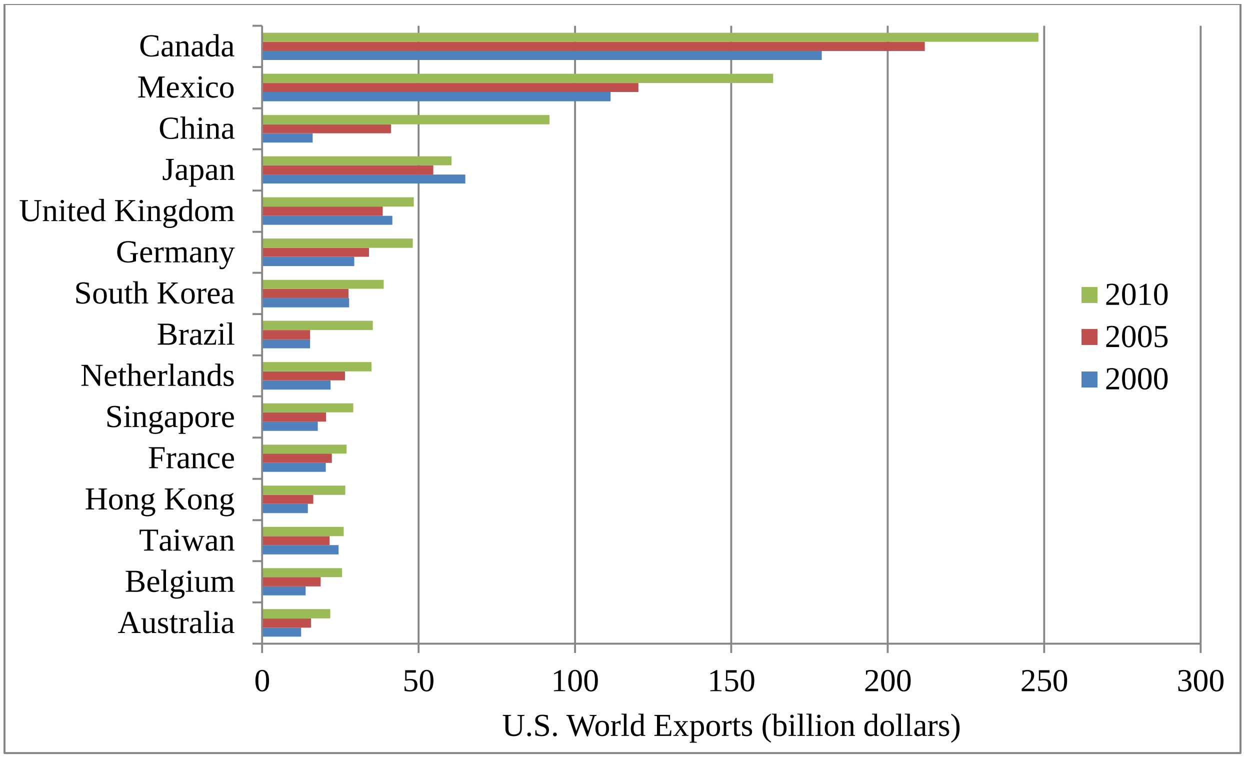
### *3.3 Ports and Inland Waterways*

Ocean ports are one of the most vital hubs for U.S. international trade flows. Congestion and low efficiency result in delays and disruptions, which impact the entire supply chain (Blonigen and Wilson, 2006). Clark et al., (2004) show that an increase in port efficiency from 25$^{th}$ to 75$^{th}$ percentile reduces port shipping costs by 12%. In addition to port efficiency, an increase in the inland transport infrastructure efficiency from 25$^{th}$ to 75$^{th}$ percentile improves the bilateral trade by 25%. This estimate is comparable to the estimate of 28% reported in Limao and Venables, (2001). Port efficiency can be measured by linking its impact on transportation costs. In their investigation of the transportation cost determinants, Sánchez et al. (2003) found statistically significant positive correlation between transport costs and distance and value per weight variables. The frequency of services and the level of containerization were both negatively correlated, but only the frequency of services was found to be statistically significant.

Waterborne imports and exports account for about 1.4 billion tons, an equivalent of $3.95 TN in international trade, and U.S. ports secure about 13.3 million jobs that generate about $649 billion in personal income (AAPA, 2010). Improving the capacity and efficiency of U.S. public ports infrastructure is particularly important given the projected increases in freight shipment for the next decade. According to the U.S. Department of Transportation, the volume of containerized cargo will double by 2020 (BTS RITA, 2009).

U.S. total exports to the top 15 countries for 2000, 2005, and 2010 are compared in Figure 7. Compared to 2000 and 2005 levels, exports in 2010 were increased significant especially for Canada, Mexico and China. Except for Japan, 2010 exports to all 15 countries are increased.

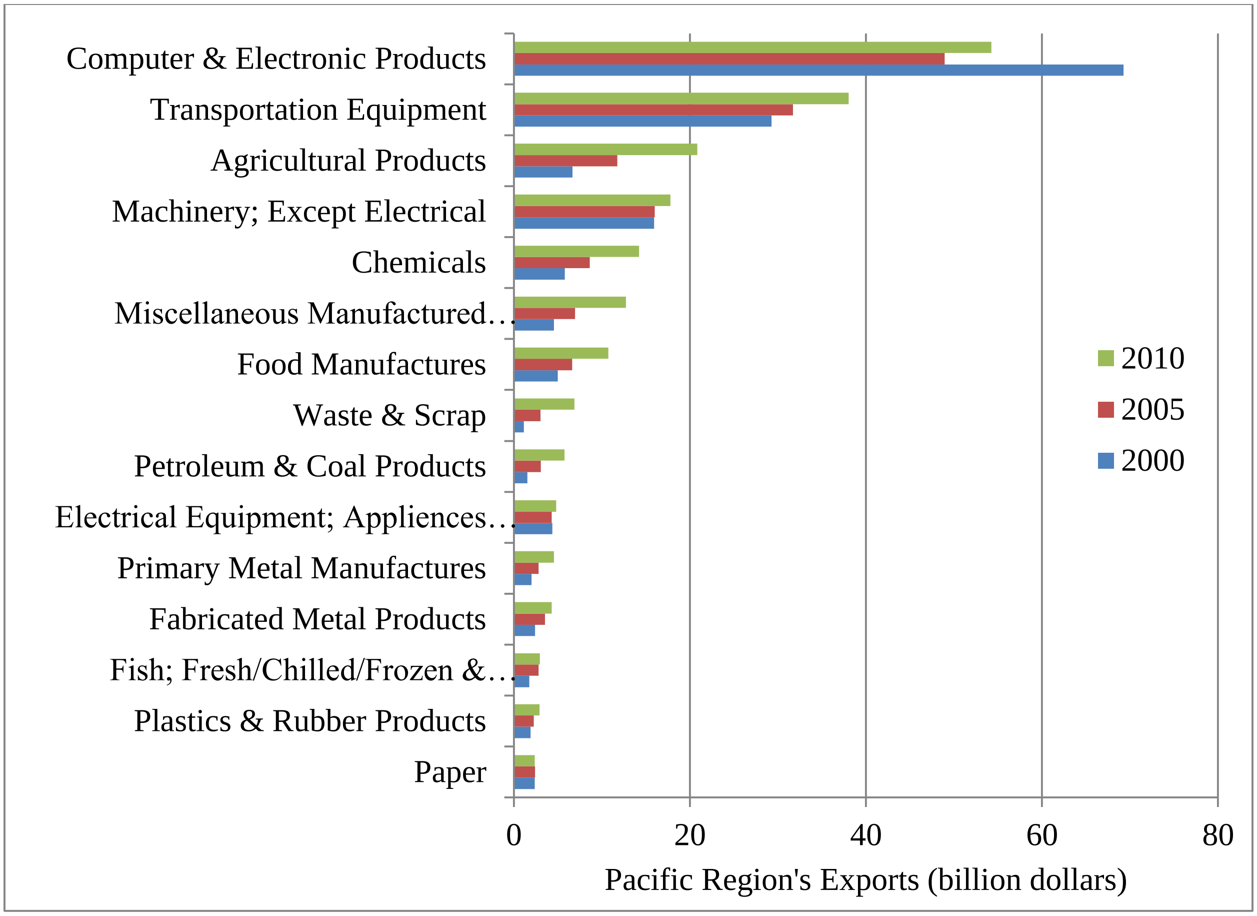
**Figure 7:** U.S. Total Exports to Top 15 Countries




Data source: U.S. Department of Commerce, International Trade Administration. Export Statistics Database - Global Patterns of U.S. Merchandise Trade (http://tse.export.gov/TSE/TSEhome.aspx)

This increasing trend in U.S. merchandise is directly comparable to agricultural export statistics discussed above. Figure 8 shows the Pacific region's top 15 export product categories. Even with a decreased 2010 level, the computer and electronics category still provides the highest exports, followed by the transportation equipment category. Agricultural products exports category is the third, with substantial increases from 2000 to 2010.

**Figure 8:** U.S. Pacific Region's Export Product Profile for Top 15 Categories

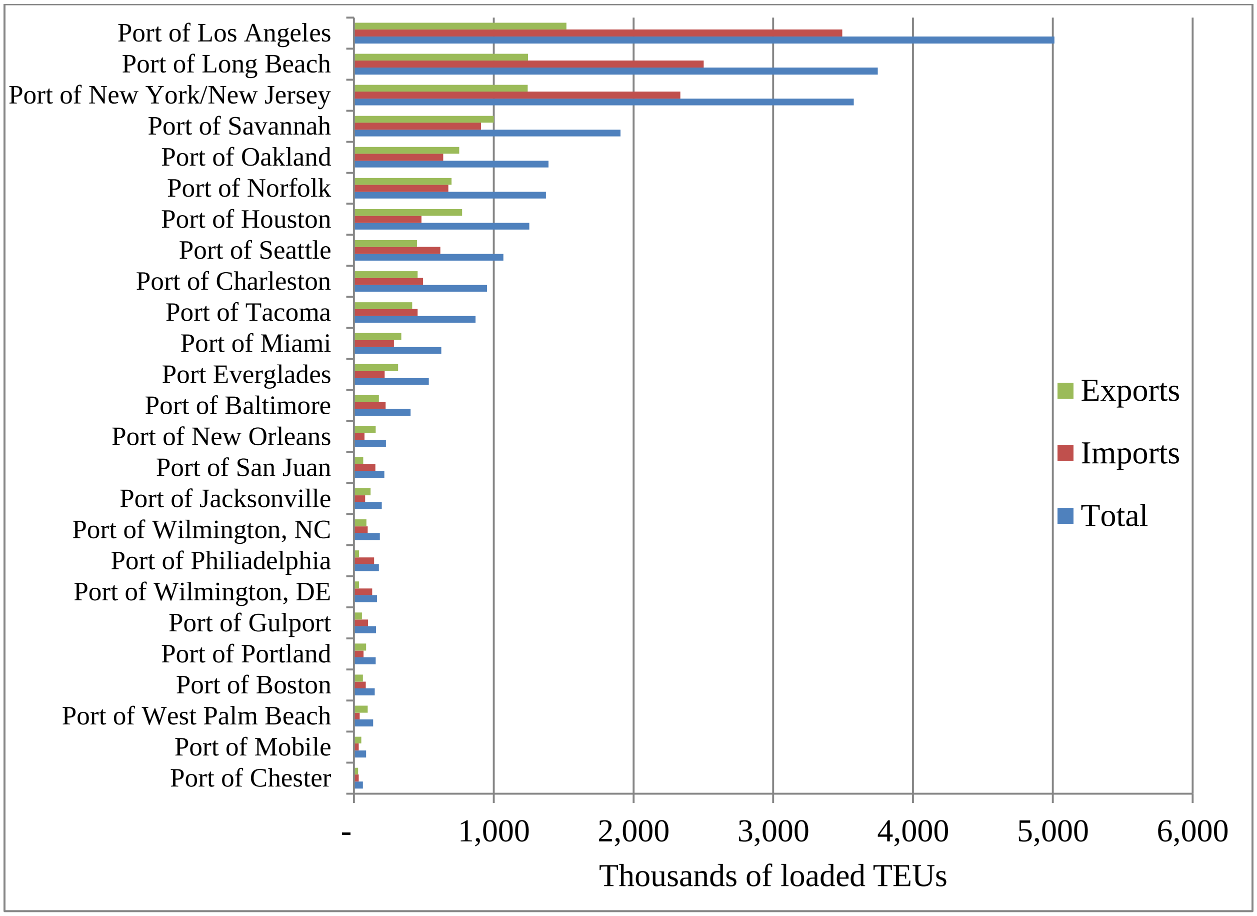



Data source: U.S. Department of Commerce, International Trade Administration. Export Statistics Database - Global Patterns of U.S. Merchandise Trade (http://tse.export.gov/TSE/TSEhome.aspx)

Among the Pacific ports, Port of Los Angeles provides the highest number of import and export twenty-foot equivalent units (TEUs) followed by Port of Long Beach, Port of Oakland, Port of Seattle, Port of Tacoma and Port of Portland (Figure 9). With the exception of Port of Oakland, imports exceed exports at all of the Pacific ports. In particular, the three biggest ports import twice of the export volumes.[2]

[2] Top merchandise exporting and importing countries' and trade volumes are provided in the Table 5 and Table 6 of the Appendix.

**Figure 9:** U.S. Top 25 Container Ports for Waterborne Trade




Data source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.
http://www.bts.gov/publications/americas_container_ports/2011/
Note: TEU = 20ft equivalent unit.

The increased levels of U.S. total merchandise and agricultural commodities exports emphasize the importance of both port and inland waterways infrastructure improvements. One of those improvement projects is the recent lock repair project on Columbia-Snake River System (CSR) by the Army Corps of Engineers that operates about 12,000 miles of waterways in the US. The CSRS links the Pacific Northwest (PNW) economy to the rest of the world through the 16$^{th}$ largest container port in the U.S. – the Port of Portland.  This waterway system is a gateway for

37% of U.S. wheat exports, 70% of U.S. barley exports, and most of the West Coast's forest/paper products and bulk mineral products exports. It is also number one for West Coast auto imports (Bureau of Transportation Statistics, 2009). The CSRS was shut down for about 15 weeks for replacing downstream gates on three dams' navigation locks, some of which were replaced 54 (The Dalles Dam) and 40 years ago (John Day Dam). The material and construction modernization of the aging infrastructure of the CSRS will allow the new locks last longer, be more efficient, and better serve this vital commerce waterway that averages about 10M tons of cargo movement, worth of more than $3 B/year.

## 4. Conclusions and Discussion

will finalize conclusions after making the necessary edits based on your review/comments

It is important to re cognize that the inference about the impact of transport infrastructure improvements on the economic growth can be complicated. The conclusions depend on whether a particular study investigates the investment impact of a single segment of infrastructure, or the impact from an aggregate investment. Generalizations from a single infrastructure segment investigation to aggregate economic impacts need to be made cautiously. Similarly, direct application of the relationship found in aggregate analysis to individual investment scenarios is not simple. The projection of future demand for measuring the utilization level of improved transport efficiencies is another important factor for evaluating the user benefits resulting from the infrastructure investment. Common cost-benefit analyses evaluate the user benefits, including reduced costs, relief of congestion and accidents. However, these methods exclude the potential regional spillover effects from improved transport networks.

## Appendix

**Table 4:** Top 10 U.S. Export Destinations for Wheat, Corn, Soybeans, and Cotton

| Commodity | | Jan.-Dec. 2009 | Jan.-Dec. 2010 | Dec. 2009 | Dec. 2010 |
|---|---|---|---|---|---|
| **Wheat** | Unit: Metric Tons | | | | |
| Nigeria | | 2,935,188 | 3,381,095 | 272,833 | 216,387 |
| Japan | | 3,035,944 | 3,169,721 | 273,383 | 153,758 |
| Mexico | | 1,921,255 | 2,433,924 | 120,137 | 264,535 |
| Philippines | | 1,261,834 | 1,721,657 | 39,936 | 102,372 |
| Egypt | | 681,728 | 1,562,995 | 0 | 395,148 |
| South Korea | | 1,108,254 | 1,528,003 | 55,898 | 149,316 |
| European Union-27 | | 545,929 | 1,050,789 | 32 | 145,310 |
| Taiwan | | 861,826 | 819,488 | 94,335 | 110,945 |
| Peru | | 373,178 | 799,416 | 0 | 0 |
| Colombia | | 336,357 | 682,863 | 24,685 | 0 |
| World Total | | 21,919,981 | 27,592,015 | 1,483,328 | 2,328,176 |
| **Corn** | | | | | |
| Japan | | 15,130,892 | 15,491,268 | 1,241,225 | 1,645,105 |
| Mexico | | 7,159,794 | 7,891,936 | 516,336 | 429,246 |
| South Korea | | 6,039,770 | 7,004,990 | 341,440 | 711,126 |
| Egypt | | 2,272,827 | 3,614,659 | 9,860 | 306,007 |
| Taiwan | | 3,752,532 | 2,937,581 | 307,609 | 225,661 |
| Canada | | 1,899,852 | 1,545,408 | 205,421 | 62,441 |
| China | | 148,251 | 1,454,887 | 58,480 | 53 |
| Syria | | 493,061 | 1,321,350 | 0 | 66,991 |
| Venezuela | | 1,294,919 | 1,054,738 | 34,462 | 5,000 |
| Dominican Republic | | 964,204 | 898,661 | 116,209 | 79,771 |
| World Total | | 47,501,791 | 50,735,249 | 3,397,419 | 4,051,991 |
| **Soybeans** | | | | | |
| China | | 22,817,676 | 24,343,197 | 3,998,274 | 3,443,435 |
| Mexico | | 3,281,264 | 3,586,832 | 280,589 | 231,921 |
| European Union-27 | | 1,989,022 | 2,578,317 | 445,573 | 322,032 |
| Japan | | 2,501,086 | 2,551,119 | 264,674 | 293,136 |
| Indonesia | | 1,483,650 | 1,849,843 | 254,166 | 201,137 |
| Taiwan | | 1,726,042 | 1,441,223 | 111,268 | 70,592 |
| Egypt | | 1,131,093 | 982,786 | 42,119 | 66,865 |
| South Korea | | 612,624 | 720,792 | 66,859 | 83,919 |
| Turkey | | 811,344 | 624,414 | 260,393 | 42,070 |
| Thailand | | 440,573 | 467,585 | 40,080 | 105,183 |
| World Total | | 40,372,076 | 42,324,568 | 6,149,220 | 5,329,069 |
| **Cotton** | | | | | |

| | | | | |
|---|---|---|---|---|
| China | 606,238 | 1,057,641 | 53,326 | 136,872 |
| Turkey | 397,948 | 460,086 | 24,716 | 56,119 |
| Mexico | 292,852 | 315,052 | 19,242 | 17,220 |
| Indonesia | 186,334 | 151,562 | 5,798 | 24,015 |
| Vietnam | 141,272 | 135,126 | 7,859 | 24,101 |
| Thailand | 128,831 | 133,210 | 8,471 | 20,720 |
| Taiwan | 86,081 | 100,617 | 6,670 | 12,676 |
| Bangladesh | 89,621 | 80,106 | 2,773 | 4,810 |
| South Korea | 63,740 | 79,176 | 3,206 | 7,672 |
| Peru | 48,691 | 75,829 | 4,931 | 10,925 |
| World Total | 2,540,405 | 2,961,425 | 169,314 | 369,851 |

Sources: Foreign Agricultural Trade of the United States (FATUS).
Website: http://www.ers.usda.gov/Data/FATUS/

**Table 5:** Top Merchandise Exporting Countries' Exports to the U.S. (2008, millions of dollars)

| Rank in 2008 | Country | Total exports | Share of world total exports (%) | Exports to U.S. | Exports to U.S. as share of country's total (%) |
|---|---|---|---|---|---|
| | World | 16,044,000 | 100.0 | 2,063,720 | 12.9 |
| 1 | China | 1,469,280 | 9.2 | 273,129 | 18.6 |
| 2 | Germany | 1,465,200 | 9.1 | 104,728 | 7.1 |
| 3 | United States | 1,300,190 | 8.1 | NA | NA |
| 4 | Japan | 783,149 | 4.9 | 139,022 | 17.8 |
| 5 | The Netherlands | 633,842 | 4.0 | 24,837 | 3.9 |
| 6 | France | 606,623 | 3.8 | 35,013 | 5.8 |
| 7 | Italy | 539,933 | 3.4 | 33,905 | 6.3 |
| 8 | Belgium | 477,159 | 3.0 | 23,095 | 4.8 |
| 9 | United Kingdom | 460,693 | 2.9 | 63,765 | 13.8 |
| 10 | Canada | 456,485 | 2.8 | 354,687 | 77.7 |
| 11 | Russia | 456,075 | 2.8 | 15,285 | 3.4 |
| 12 | South Korea | 426,763 | 2.7 | 46,501 | 10.9 |
| 13 | Hong Kong | 362,985 | 2.3 | 46,290 | 12.8 |
| 14 | Singapore | 339,414 | 2.1 | 24,196 | 7.1 |
| 15 | Mexico | 291,343 | 1.8 | 233,523 | 80.2 |
| 16 | Saudi Arabia | 285,928 | 1.8 | 51,823 | 18.1 |
| 17 | Spain | 267,581 | 1.7 | 11,229 | 4.2 |
| 18 | Malaysia | 224,490 | 1.4 | 28,321 | 12.6 |
| 19 | Switzerland | 200,065 | 1.2 | 19,221 | 9.6 |
| 20 | Brazil | 197,067 | 1.2 | 28,558 | 14.5 |
| 21 | India | 191,926 | 1.2 | 24,483 | 12.8 |
| 22 | Australia | 185,693 | 1.2 | 10,290 | 5.5 |
| 23 | Sweden | 184,000 | 1.1 | 12,091 | 6.6 |
| 24 | Austria | 181,737 | 1.1 | 7,802 | 4.3 |
| 25 | Thailand | 173,235 | 1.1 | 19,754 | 11.4 |
| 26 | Unit. Arab Emir. | 170,126 | 1.1 | 1,225 | 0.7 |
| 27 | Poland | 169,074 | 1.1 | 2,481 | 1.5 |
| 28 | Norway | 167,976 | 1.0 | 7,499 | 4.5 |
| 29 | Czech Republic | 146,767 | 0.9 | 2,580 | 1.8 |
| 30 | Indonesia | 137,022 | 0.9 | 13,080 | 9.5 |
| 31 | Turkey | 132,311 | 0.8 | 4,398 | 3.3 |
| 32 | Ireland | 124,468 | 0.8 | 23,005 | 18.5 |
| 33 | Denmark | 116,974 | 0.7 | 6,223 | 5.3 |

| | | | | | |
|---|---|---|---|---|---|
| 34 | Venezuela | 115,648 | 0.7 | 47,828 | 41.4 |
| 35 | Hungary | 108,017 | 0.7 | 2,499 | 2.3 |
| 36 | Iran | 107,413 | 0.7 | 96 | 0.1 |
| 37 | Finland | 96,837 | 0.6 | 6,199 | 6.4 |
| 38 | Nigeria | 77,380 | 0.5 | 35,652 | 46.1 |
| 39 | Algeria | 76,642 | 0.5 | 18,211 | 23.8 |
| 40 | Argentina | 73,372 | 0.5 | 5,616 | 7.7 |
| 41 | South Africa | 73,005 | 0.5 | 8,083 | 11.1 |
| 42 | Slovakia | 71,047 | 0.4 | 1,212 | 1.7 |
| 43 | Chile | 71,011 | 0.4 | 7,856 | 11.1 |
| 44 | Kuwait | 67,382 | 0.4 | 6,727 | 10.0 |
| 45 | Ukraine | 66,884 | 0.4 | 1,949 | 2.9 |
| 46 | Qatar | 62,396 | 0.4 | 473 | 0.8 |
| 47 | Angola | 62,160 | 0.4 | 17,725 | 28.5 |
| 48 | Israel | 61,372 | 0.4 | 19,972 | 32.5 |
| 49 | Vietnam | 60,813 | 0.4 | 12,594 | 20.7 |
| 50 | Libya | 60,645 | 0.4 | 3,954 | 6.5 |
| | Rest of the world | 1,406,403 | 8.8 | 175,031 | 12.4 |

Source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Website: http://www.bts.gov/programs/freight_transportation/

**Table 6:** Top Merchandise Importing Countries' Imports from the U.S. (2008, millions of dollars)

| Rank in 2008 | Country | Total imports | Share of world total imports (%) | Imports from U.S. | Imports from U.S. as share of country's total (%) |
|---|---|---|---|---|---|
| | World | 16,708,900 | 100 | 1,340,520 | 8 |
| 1 | United States | 2,166,020 | 13 | NA | NA |
| 2 | Germany | 1,204,750 | 7.2 | 50,399 | 4.2 |
| 3 | China | 1,196,750 | 7.2 | 80,723 | 6.7 |
| 4 | Japan | 761,803 | 4.6 | 78,974 | 10.4 |
| 5 | France | 706,670 | 4.2 | 30,274 | 4.3 |
| 6 | United Kingdom | 634,542 | 3.8 | 55,192 | 8.7 |
| 7 | The Netherlands | 573,758 | 3.4 | 43,368 | 7.6 |
| 8 | Italy | 556,328 | 3.3 | 17,355 | 3.1 |
| 9 | Belgium | 470,194 | 2.8 | 26,112 | 5.6 |
| 10 | Canada | 449,077 | 2.7 | 235,479 | 52.4 |
| 11 | South Korea | 435,275 | 2.6 | 38,556 | 8.9 |
| 12 | Spain | 403,045 | 2.4 | 13,893 | 3.4 |
| 13 | Hong Kong | 388,947 | 2.3 | 19,541 | 5 |
| 14 | Mexico | 339,464 | 2 | 166,468 | 49 |
| 15 | Singapore | 319,779 | 1.9 | 37,853 | 11.8 |
| 16 | India | 304,166 | 1.8 | 20,533 | 6.8 |
| 17 | Russia | 274,284 | 1.6 | 12,204 | 4.4 |
| 18 | Brazil | 229,877 | 1.4 | 34,233 | 14.9 |
| 19 | Australia | 211,111 | 1.3 | 25,346 | 12 |
| 20 | Poland | 205,148 | 1.2 | 2,973 | 1.4 |
| 21 | Turkey | 201,964 | 1.2 | 11,977 | 5.9 |
| 22 | Unit. Arab Emir. | 190,203 | 1.1 | 17,324 | 9.1 |
| 23 | Austria | 184,501 | 1.1 | 3,306 | 1.8 |
| 24 | Switzerland | 183,002 | 1.1 | 10,612 | 5.8 |
| 25 | Malaysia | 181,851 | 1.1 | 14,543 | 8 |
| 26 | Thailand | 178,526 | 1.1 | 11,375 | 6.4 |
| 27 | Sweden | 167,686 | 1 | 5,290 | 3.2 |
| 28 | Czech Republic | 141,703 | 0.8 | 1,709 | 1.2 |
| 29 | Indonesia | 129,274 | 0.8 | 7,898 | 6.1 |
| 30 | Saudi Arabia | 111,274 | 0.7 | 13,726 | 12.3 |
| 31 | Denmark | 111,199 | 0.7 | 3,355 | 3 |
| 32 | Hungary | 108,241 | 0.6 | 1,531 | 1.4 |

| | | | | | |
|---|---|---|---|---|---|
| 33 | South Africa | 99,561 | 0.6 | 7,817 | 7.9 |
| 34 | Finland | 92,108 | 0.6 | 1,849 | 2 |
| 35 | Portugal | 90,191 | 0.5 | 1,522 | 1.7 |
| 36 | Norway | 89,078 | 0.5 | 4,818 | 5.4 |
| 37 | Ukraine | 85,533 | 0.5 | 2,813 | 3.3 |
| 38 | Vietnam | 84,196 | 0.5 | 3,069 | 3.6 |
| 39 | Ireland | 83,758 | 0.5 | 9,689 | 11.6 |
| 40 | Romania | 82,995 | 0.5 | 1,207 | 1.5 |
| 41 | Philippines | 79,471 | 0.5 | 9,145 | 11.5 |
| 42 | Greece | 79,348 | 0.5 | 2,325 | 2.9 |
| 43 | Slovakia | 73,442 | 0.4 | 459 | 0.6 |
| 44 | Iran | 69,374 | 0.4 | 752 | 1.1 |
| 45 | Israel | 65,155 | 0.4 | 8,034 | 12.3 |
| 46 | Egypt | 63,431 | 0.4 | 6,634 | 10.5 |
| 47 | Venezuela | 56,984 | 0.3 | 13,872 | 24.3 |
| 48 | Chile | 55,960 | 0.3 | 10,689 | 19.1 |
| 49 | Nigeria | 54,519 | 0.3 | 4,512 | 8.3 |
| 50 | Argentina | 54,033 | 0.3 | 8,292 | 15.3 |
| | Rest of the world | 1,629,351 | 9.8 | 150,900 | 9.3 |

Source: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Website: http://www.bts.gov/programs/freight_transportation/

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