**Improving expenditure profiles for port economic impact analysis through tariff data**

**Wen-Huei Chang\***

**Yue Cui\*\***

**Ed Mahoney\*\***

*\* US Army Corp of Engineers: Institute for Water Resources*

*\*\* Michigan State University*

**Keyword: port, economic impacts, cargo movement, tariff**

**Abstract**

Navigation is one of the US Corps of Engineers’ (USACE) major missions. The USACE’s Institute for Water Resources (IWR) has developed an economic impact analysis tool, called Regional Economic System (RECONS), to estimate job creation and retention and other economic measures such as value added, income, and sales for various USACE related activities, including Crops’ navigation program. As a new component of RECONS, this study will aim to 1) define the categories of port industry revenues that directly supporting the movement of goods through the ports, and identify the expenditures on services that are essential to moving cargo through the port system. 2) develop convert factors to translate port charges to per commodity-cargo type-unit format and build expenditure profile based on the standard port charges, and 3) develop a model to simulate the economic impacts based on the changes of cargo flows through the ports.

**Introduction**

Navigation is one of the US Corps of Engineers’ (USACE) major missions. There are 926 harbors located in US maintained by the Corps which virtually affect all 50 states and other nations in terms of their economic significance. The nation’s coastal transportation system encompasses a network of navigable channels, ports, harbors, and other infrastructure maintained by the Corps, as well as publicly and privately owned vessels, terminals, inter-modal connections, shipyards, and repair facilities. Coastal navigation is not only a key element of state and local government’s economic development and job-creation efforts, but also essential in maintaining global competitiveness and national security.

Improvements to the navigation system funded by the federal government and implemented by the Corps are subject to a detailed benefit-cost analysis which could include quantification of benefits that accrue at both the national level and regional level. The USACE’s Institute for Water Resources (IWR) has developed an economic impact analysis tool, called Regional Economic System (RECONS), to estimate job creation and retention and other economic measures such as value added, income, and sales for various USACE related activities, including Crops’ navigation program.

The economic impact studies on US ports can be categorized as cargo movement, local ports users, and capital investments ([U.S. Maritime administration, 1985](#_ENREF_9)). Practitioners and scholars mostly focused on measuring impacts of local port users and capital investment. Government agencies such as the US Maritime Administration and US Army Corps of Engineers have developed simulation models (e.g., Port Kits and RECONs) to estimate the impacts of cargo movement. As cargo movement is the element most closely tied to a port’s existence, it is often the core component of measuring a port economic impact. For simulation purposes, expenditure associated with cargo movement through the port system has to be standardized as model input either by per commodity type, per cargo type, or per unit. However, getting updated cargo movement data for US ports for regional economic impact analysis remains a challenge in recent years. For example, the Port Kits’ spending profiles have not been updated since 2000. The typical ways of obtaining expenditure data are through professional estimates or ad hoc survey methods such as in the Port Kits which telephone interviews and mail-in surveys with major shippers were administered. However, the small sample size, complexity of port operation and charging units, the missing or ambiguous data make the reliability, accuracy and representativeness of the expenditure dataset questionable. In addition, time and cost budget are also barriers for updating the expenditure data in a sustainable and consistent fashion.

On the other hand, most major ports in US publish tariff data on an annual basis, which provides the rate that ports charge for various services related to cargo flows. Port tariffs are based on a mix of pricing strategies designed to reflect the demand for port services, the competition between ports, and the cost of providing the services ([Heggie, 1974](#_ENREF_5); [Strandenes & Marlow, 2000](#_ENREF_7)). As such, port tariffs could be a solid and consistent data source to understand the expenditures related the vessels and goods moving through the ports. To improve the quality and accuracy of measuring economic impacts, this study proposes a method to build and update expenditure profile of port related services using the tariff data published by US ports.

**Literature Review**

Economic impact analysis traces changes in economic activity through the economy to measure the cumulative economic effects of an action. For example, construction and maintenance of navigation infrastructure in a region will directly contribute to businesses under the construction, services, and manufacturing sectors. There are three major methods and modeling techniques that have been applied to estimate economic impacts of ports worldwide: input-output (I-O), computable general equilibrium (CGE) and gravity models ([Bichou, 2006](#_ENREF_1); [Coto-Millán, Pesquera, & Galán, 2010](#_ENREF_2)). I-O models, including RIMS II and IMPLAN, are applied to the majority of port economic impact studies in US. For example, the US MARAD’s Port Economic Impact Kit ([U.S. Maritime administration, 1985](#_ENREF_9)), Rural Inland Waterways Economic Impact Kit ([Hamilton, Rasmussen, Zeng, & Arkansas, 2000](#_ENREF_4)), and Martin Associations ports economic impact studies ([Martin Associates, 2015](#_ENREF_6)). The criticism of the I-O model is that the production functions are static, and therefore it is difficult to predict the economic responses to changes in prices, demand, or a catastrophic event. Alternatively, computable general equilibrium (CGE) captures the inter-relationships among sectors of an economy, including household, industry, government, and external sectors. It also incorporates market mechanisms and price incentives within a general equilibrium framework. CGE models have been utilized in general EIA as well as port efficiency studies. For example, [Tiwari and Itoh (2001](#_ENREF_8)) applied CGE model to analyze the system-wide impact of increased efficiency of ports in Japan. [Haddad, Hewings, Perobelli, and Santos (2010](#_ENREF_3)) analyzed port’s efficiency through the link among trade barriers and subsequent growth and regional inequality in Brazil. Typical limitation for CGE is that the models contain a large number of variables and parameters and are structurally complex. Higher costs and parameter uncertainty also limit the use of CGE models. Gravity model is also employed in port economic studies. For example, [Wilson, Mann, and Otsuki (2003](#_ENREF_10)) explore port efficiency in terms of the relationship between trade facilitation, trade flows economic development in the Asia-Pacific region.

As a component of RECONS, this study utilizes the standard I-O model to estimate the economic impacts of commercial shipping (cargo movement) through the coastal ports in United States.

Reliable estimates of the regional effects of the cargo movement require precise and current measures of money spent (spending profile) on port services and the moving commodities from/to hinterland. The spending profile was highly variable across regions and types of ports. The development of spending profiles by port type and commodity types needs to be accomplished through a comprehensive approach that includes data analysis, research, and interviews.

The latest cargo movement related economic impacts study is the Port Kits, in which the spending profiles of economic impacts activities regarding the cargo movement is by telephone interview and paper-based survey. The reliability, accuracy and the ability to update the data in a timely fashion are questionable. Therefore, we propose a method to develop spending profiles through port tariff information.

The port tariff reflects the types of services offered to the port users ([Strandenes & Marlow, 2000](#_ENREF_7)). The port tariff lists the public rates that port charges for various services including vessel services, cargo services, hinterland transportation, warehousing, security, etc. These rates are affected by a variety of factors, including the nature of the commodities carried/handled, the types of vessels and the types of cargos used. [Heggie (1974](#_ENREF_5)), ([Martin Associates, 2015](#_ENREF_6); [Strandenes & Marlow, 2000](#_ENREF_7)) classified the port-related services based on above factors from different perspectives. For example, [Strandenes and Marlow (2000](#_ENREF_7)) classified the port related tariff rates as Tonnage related dues, cargo related dues, passage related dues and dues associated with miscellaneous services. [Martin Associates (2015](#_ENREF_6)) categorized port services charges as surface transportation sector, maritime services sector, banking/insurance/law services sector, and port authority.

**Study Region, Data, and Method**

The objects in this study are the 598 coastal ports in United States including Alaska and Hawaii. Major ports in United States across different regions, such as Port Los Angeles, Port Hudson, Port New Oreland, Port Miami, Port Savannah, Port New York and Port Boston, post tariff information through their websites. Other ports are able to provide tariff information by request.

Based on literature and USACE port expert interviews, we propose a framework (Figure 1) to build port related spending profiles as a component of our economic impact model input. The port related charges are varied by service types (expenditure category), cargo types, commodity types, and charging units.

Expenditure

Category

Commodity

Type

Cargo

Type

Charging

Unit

Figure 1: A framework to understanding port services related spending

The expenditure category is built based on how vessels, cargo and commodities flow in ports. It is shown in Table 1.

|  |  |
| --- | --- |
| Table 1 The categories of ports services associated with cargo movement | |
| **Major Types of Services** | **Sub Categories** |
| **Vessel & Terminal Operations** | |
|  | Costs of having ship in port: Wharfage/Dockage/Demurrage |
|  | Costs of getting ship to terminal: Pilotage/Tug Assistance & Towing/Line Handling |
|  | Shared-out Terminal and Port Operational Costs: Port/Terminal Administrative Costs |
|  | Ship Sea-side Expenditures at Port: Fuel/Supplies |
| **In-port Cargo Handling/Packing/Transfer** | |
|  | Loading and Unloading: Gentries/Pumping/Conveyance/Drayage/Hostling |
|  | Storage and Warehousing: Storage/Refrigeration/Bulk Storage/Repackaging |
|  | Inspection and Security: Clearances/Inspection/Security/Gov’t & Private |
| **Inland Transportation** |  |
|  | Truck |
|  | Rail |
|  | Pipeline |
|  | Barge |
|  | Air |
| **Miscellaneous** |  |

The cargo type in Figure 1 is listed in Table 2.

|  |
| --- |
| Table 2 Proposed Cargo Types |
| Containers |
| Break Bulk |
| Automobiles |
| Dry Bulk |
| Liquid Bulk |
| Project Cargo |
| Other |

The commodity types, which fit the requirement of USACE, is listed in Table 3.

| Table 3 Proposed Commodity Types |
| --- |
| Aggregates |
| Chemicals |
| Coal |
| Crude Petroleum |
| Grains and Grain Products |
| Iron Ore & Iron & Steel Products |
| Non-Metallic Ores and Minerals |
| Petroleum Products |
| Others |

Unlike most Europe countries with a uniform charging unit (gross ton) in port tariffs, the charging units in US ports are varied dramatically based on the nature of the services. For example, the Wharfage might be charged by the number of feet per vessel while the crane rental is based on the usage hours. Different ports might have their own charging and measurement unit. Therefore, a convert factor will be developed based on transform the rates based on different charging units to the short ton unit. The spending profiles regarding the economic activities moving cargos through the ports will be built based on Figure 1 and the convert factors.

Next, the economic impacts of cargo movement through the ports are estimated (shown in Figure 2).

Choose a port

Choose Impact Regions –

Region, Multi-State Region, and Nation

Identify Tons Shipped through the ports by Commodity Type and Cargo Type

Associated Impact Regions

Spending per Ton

by spending category, Commodity Type, and Cargo Type

Spending by IMPLAN Industries

IMPLAN Multipliers

Economic Impacts

Figure 2 RECONS and User Input / Output

**Preliminary Result**

In total, we collected tariff documents from 50 ports. The ports with shipping volumes in 2012, region and publish date of tariff documents are listed in Table 4. The data shows that the ports in this study are distributed along the coast of Pacific Ocean, Gulf of Mexico, Atlantic Ocean, and Great Lakes. This list includes major large ports in United States. About 98% ports have shipping volumes over one million tons in 2012. In addition, 78% tariff documents are published within recent two years (2014 and 2015). This suggests that the spending profiles of port servers built on these tariff information are up to date and could represent the public rates for port services in United States in some degree.

| Table 4 The list of ports with tariff documents by May 05, 2015 | | |  |
| --- | --- | --- | --- |
| **Port Name** | **Total Shipping Volume (Tons) in 2012** | **Region** | **Publish Year** |
|
| Anacortes, WA | 11,743,390 | Pacific | 7/1/2014 |
| Anchorage, AK | 2,842,912 | Pacific | 1/1/2015 |
| Baltimore, MD | 42,102,106 | Atlantic | 12/1/2014 |
| Beaumont, TX | 78,515,010 | Gulf of Mexico | 6/1/2014 |
| Boston, MA | 16,315,050 | Atlantic | 12/1/2014 |
| Brownsville, TX | 5,600,977 | Gulf of Mexico | 3/1/2007 |
| Charleston, SC | 19,105,017 | Atlantic | 5/15/2015 |
| Chicago, IL | 17,090,171 | Great Lakes | 4/1/1983 |
| Cleveland, OH | 11,313,415 | Great Lakes | 5/1/2015 |
| Corpus Christi, TX | 68,999,821 | Gulf of Mexico | 3/8/2011 |
| Detroit, MI | 5,346,800 | Great Lakes | 10/1/2007 |
| Everett, WA | 1,479,039 | Pacific | 7/1/2014 |
| Freeport, TX | 22,084,551 | Gulf of Mexico | 4/20/2015 |
| Grays Harbor, WA | 1,902,845 | Pacific | 1/1/2015 |
| Houston, TX | 238,185,582 | Gulf of Mexico | 1/1/2015 |
| Indiana Harbor, IN | 13,164,061 | Great Lakes | 1/1/2007 |
| Jacksonville, FL | 15,415,144 | Atlantic | 10/3/2014 |
| Lake Charles, LA | 54,378,996 | Gulf of Mexico | 1/26/2015 |
| Long Beach, CA | 77,384,974 | Pacific | 4/13/2015 |
| Longview, WA | 12,192,962 | Pacific | 3/1/2015 |
| Los Angeles, CA | 61,819,495 | Pacific | 1/13/2014 |
| Miami, FL | 6,993,927 | Atlantic | 10/1/2014 |
| Milwaukee, WI | 2,267,094 | Great Lakes | 5/1/2014 |
| Mobile, AL | 54,887,669 | Gulf of Mexico | 3/3/2015 |
| Morehead City, NC | 3,248,655 | Atlantic | 2/1/2015 |
| New Orleans, LA | 79,342,141 | Rivers and inland | 2/1/2015 |
| New York, NY and NJ | 132,039,959 | Atlantic | 9/1/2014 |
| Newport News, VA | 30,508,064 | Atlantic | 9/1/1994 |
| Oakland, CA | 18,728,247 | Pacific | 11/1/1988 |
| Palm Beach, FL | 2,065,402 | Atlantic | 11/1/2014 |
| Panama City, FL | 2,326,263 | Gulf of Mexico | 10/1/2014 |
| Pascagoula, MS | 33,784,810 | Gulf of Mexico | 11/8/1988 |
| Pensacola, FL | 878,644 | Gulf of Mexico | 1/15/2015 |
| Plaquemines, LA, Port of | 58,280,348 | Gulf of Mexico | 11/13/2014 |
| Port Canaveral, FL | 3,164,186 | Atlantic | 10/1/2014 |
| Port Everglades, FL | 21,688,988 | Atlantic | 10/1/2014 |
| Port Hueneme, CA | 1,541,450 | Pacific | 6/7/2010 |
| Port Manatee, FL | 3,396,673 | Gulf of Mexico | 2/19/2015 |
| Portland, ME | 667,561 | Pacific | 3/1/2015 |
| Redwood City, CA | 916,776 | Pacific | 7/1/2014 |
| Richmond, CA | 22,555,921 | Pacific | 7/1/2014 |
| San Diego, CA | 1,368,346 | Pacific | 11/1/2014 |
| San Francisco, CA | 3,460,059 | Pacific | 1/1/2009 |
| Seattle, WA | 23,748,337 | Pacific | 5/14/2015 |
| South Louisiana, LA, Port of | 252,069,033 | Gulf of Mexico | 11/13/2013 |
| Tacoma, WA | 24,918,310 | Pacific | 1/19/2015 |
| Tampa, FL | 31,650,258 | Gulf of Mexico | 10/1/2006 |
| Texas City, TX | 56,721,627 | Gulf of Mexico | 1/1/2015 |
| Wilmington, DE | 5,112,762 | Atlantic | 3/1/2015 |
| Wilmington, NC | 6,718,650 | Atlantic | 2/1/2015 |

As a pilot study, we collected 1835 expenditure items related to port services from nine ports’ tariff documents. The charges are classified based on the proposed method shown in Figure 1. Table 5 is the distribution of the expenditure items by commodity type, cargo type and charging unit. For commodity type, only 35% of the expenditure items are associated with certain types of commodity. The other 77% of the expenditure items do not have specific commodities. Many expenditure items are not commodity specific. For example, the charges of Wharfage are based on vessel size instead of commodities. In terms of cargos, only containers have clear expenditure segments. There are no clear patterns for other types of cargos. This might due to the sample size and the port specialties. We expect that the sample size will be increase with 50 ports tariff information comparing to the information obtained from nine ports in this pilot study. For charging units, about 40% of expenditure items are with a standard charging units, which can be converted to tons and in further be used to calculate the total expenditures in economic impacts estimates shown in Figure2. The other 60% are not with a standard unit. For example, the Wharage charges depend on the length of the vessels; the loading/unloading equipment (e.g., cranes) is charged by the usage hours. Therefore, further work, such as expert interview and survey, are needed to convert charges with various units to standard units.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 5 The distribution of expenditure items for commodities, cargo type and charging units | | | | | | | | | |
| Dimensions | Categories | Expenditures | | | | | | | Grand Total |
| Wharfage/Dockage/Demurrage | Pilotage/Tug/Line Handling | Port/Terminal Admin. Cost | Loading/Unloading | Storage and Warehousing | Inspection and Security | Miscellaneous |
| Commodities | Coal | 0.5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.2% |
| Crude Petroleum | 0.6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.2% |
| Petroleum Products | 1.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.5% |
| Grains and related | 1.4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.5% |
| Iron / Steel Products | 7.2% | 0.0% | 2.5% | 5.4% | 35.2% | 0.0% | 3.9% | 5.9% |
| Non-Metallic Ores and Minerals | 2.2% | 0.0% | 0.0% | 3.4% | 15.4% | 0.0% | 0.0% | 2.2% |
| Chemicals | 5.8% | 0.0% | 3.3% | 0.0% | 0.0% | 0.0% | 1.0% | 2.3% |
| Finished Good | 9.4% | 0.0% | 3.3% | 2.0% | 0.0% | 0.0% | 3.9% | 4.3% |
| Others | 5.0% | 1.0% | 0.0% | 14.1% | 7.7% | 0.0% | 19.9% | 4.6% |
| No-specific Commodities | 66.6% | 99.0% | 90.8% | 75.1% | 41.8% | 100.0% | 71.4% | 76.6% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Cargo Type | Container | 16.6% | 2.4% | 1.7% | 19.2% | 29.7% | 25.0% | 6.3% | 12.4% |
| Break Bulk | 0.9% | 0.0% | 0.0% | 7.1% | 46.2% | 0.0% | 2.4% | 4.3% |
| Automobiles | 3.0% | 0.0% | 0.0% | 0.3% | 1.1% | 0.0% | 2.4% | 1.4% |
| Dry Bulk | 3.4% | 0.0% | 0.8% | 0.0% | 2.2% | 0.0% | 2.9% | 1.7% |
| Liquid Bulk | 2.3% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1.0% | 0.9% |
| Project Cargo | 0.5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.2% |
| Other | 0.3% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% |
| No-specific Cargo Types | 73.0% | 97.6% | 97.5% | 73.4% | 20.9% | 75.0% | 85.0% | 79.0% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Charging Units | Standard tons | 40.5% | 7.0% | 19.2% | 22.9% | 5.5% | 0.0% | 22.3% | 24.1% |
| Can be transformed to standard tons | 15.3% | 0.7% | 42.5% | 2.3% | 90.1% | 0.0% | 20.4% | 15.5% |
| Non standard unit | 44.2% | 92.3% | 38.3% | 74.9% | 4.4% | 100.0% | 57.3% | 60.4% |
| Grand Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Discussions, Implications and Future Research**

In the information era, more and more ports make their operation information including port statistics, operation spending, revenues and tariff, available to the public through internet as a goal of information transparency. Our preliminary study found that over 78% of ports post up-to-date tariff information on their websites. In addition, the tariff documents are with the same structure to list their charges from year to year. This makes it possible for researchers to understand the ports’ characteristics, business structure and flows as well as to extract rates information in an economic and efficient way. Therefore, port tariff could be a reliable, accurate and up to date information source for estimate economic impacts of cargo movement through the ports. To authors’ best knowledge, using tariff in cargo movement effect estimates is rare in port related economic impacts studies, especially as inputs a economic impact simulation models..

On the other hand, scholar and experts question whether the port tariff information is able to reflect the cargo movement spending from different aspects. For example, the tariff is the public rate. The port will offer discount to businesses as parts of their competitive strategies. Some experts believe that the rates in tariff overestimate the actual spending. In contrast, [Strandenes and Marlow (2000](#_ENREF_7)) argued that the tariff might not be solely associated with “commercial” pricing or cost based pricing, the charges listed in tariff might underestimate the actual spending of commercial shipping due to tariff history, the ownership and the financial objectives of ports, etc. Their study region is Europe. There is no published port-related tariff and pricing studies in United States. As one of our future work, we will exam the impacts port pricing policy on cargo movement expenditure. In addition, the tariff does not only list rates for cargo movement and commercial shipping, it also lists other services related to port activities, such as passenger and cruise ship services, water-based tourism and recreation services, etc. RECONS will incorporate these components to evaluate to a comprehensive tool to estimate port economic impacts.

**Reference**

Bichou, K. (2006). Review of port performance approaches and a supply chain framework to port performance benchmarking. *Research in Transportation Economics, 17*, 567-598.

Coto-Millán, P., Pesquera, M. A., & Galán, J. C. (2010). A methodological discussion on Port Economic Impact Studies and their possible applications to policy design *Essays on Port Economics* (pp. 151-160): Springer.

Haddad, E. A., Hewings, G. J., Perobelli, F. S., & Santos, R. C. (2010). Regional effects of port infrastructure: a spatial CGE application to Brazil. *International Regional Science Review*.

Hamilton, G. L., Rasmussen, D., Zeng, X., & Arkansas, L. R. (2000). Rural Inland Waterways Economic Impact Kit Users Guide: University of Arkansas, Mack-Blackwell National Rural Transportation Study Center.

Heggie, I. G. (1974). Charging for port facilities. *Journal of transport economics and Policy*, 3-25.

Martin Associates. (2015). Port Economic Impact Studies. Retrieved April 12, 2015, from Martin Associates

Strandenes, S. P., & Marlow, P. B. (2000). Port pricing and competitiveness in short sea shipping. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, 315-334.

Tiwari, P., & Itoh, H. (2001). A computable general equilibrium analysis of efficiency improvements at Japanese ports. *Review of Urban & Regional Development Studies, 13*(3), 187-206.

U.S. Maritime administration. (1985). Port Economic Impact Kit.

Wilson, J. S., Mann, C. L., & Otsuki, T. (2003). Trade facilitation and economic development: A new approach to quantifying the impact. *The World Bank Economic Review, 17*(3), 367-389.