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Panama canal expansion, U.S. trade diversion from west coast seaports and urban innovation

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Abstract

Adapting to the rapid process of globalization requires nodes of international trade and global financial operations conveyed in the world urban system. Urban and metropolitan areas need to strategically approach to incorporating the city economic activities to enlarge the scope and complexity of the city service and commodity. Because strong urban agglomerations usually lead to technological innovation, investigating the relation between the expansion of Panama Canal and its state and regional economic impacts that will be potentially affected within the U.S. can provides various policy insights in urban growth and technical innovations for the local areas. This study estimated reduced impacts of transportation and warehousing activities for foreign imports and exports for the west coast seaports of California, Oregon, and Washington as well as the concurrent impacts in other states stemming from the trade diversion in their direction, which will affect urban growth and innovation. We applied both the supply- and demand-side National Interstate Economic Models. We assumed that foreign imports and exports that currently arrive and leave the west coast customs district ports and are now transported to other U.S. Southern and East Coast states by truck and rail modes would be directly shipped to these other states via the deepened and expanded Panama Canal. The total negative impacts of transportation and warehousing values lost in the three west coast states from foreign import diversion were estimated to be $5795 million; for foreign exports, $1630 million. However, total positive gains due to the shift of transportation modes and new warehousing activities for foreign imports in the other states were estimated at $6304 million, while the gains were $9218 million for the case of foreign exports. The net impacts resulting from port modernization investment and shipping route changes will be an economic engine to affect U.S. states.

Keywords: Panama canal expansion, Economic model, NIEMO, West coast seaports, Economic impacts

Introduction

The Panama Canal Authority in 2006 decided to invest more than $5 billion to expand the Canal to increase container shipment capacity. The expanded Canal will accommodate larger vessels that cannot now traverse the facility. Along with capacity expansion, the project is expected to have significant impacts on U.S. water and ground carriers, including transportation systems relating to cargo distribution, port development, U.S.

supply chains, and logistics. According to CanagaRetna (2013) and Knight (2008), the expansion will induce an even greater flow of container trade between Asian countries and the U.S., and hence, trade volumes arriving at Gulf and Atlantic Coast ports are also expected to increase as shipping cargo shifts from the congestion experienced in West Coast ports.

Urban economic growth in urban cities is mainly geared by urban innovation process. Urban innovation process is reached by deepening by capital and increasing in human resource through technologically innovative progress and agglomeration economies in urban areas. Urban cities are rapidly experiencing globalization process. Adapting to the process requires nodes of international trade and global financial operations conveyed in the world urban system. Urban cities need to strategically approach to incorporating the city economic activities to enlarge the scope and complexity of the city's service and commodity activities. This comprises strong urban agglomerations that usually lead to technological innovation, increasing per-capita income of residents and laborers in urban cities.

Investigating the relationship between the expansion of Panama Canal and its state and regional economic impacts that will be potentially affected within the U.S. can provides various policy insights in urban growth and technical innovations in the U.S. For example, while West Coast cities may have inverse experiences, increase in international trade in East Coast cities may experience technological innovations through the new modernization investment process in bays and port facilities, which in turn lead to urban growth. Changes in international trade patterns and activities of transportation industry draw various discussions in technological innovations. Through this study, stakeholders of the canal expansion and policy makers will get basic grounds of their decision making process of investment adapted to globalization and new technical innovation process needed to expand their port capacities.

However, estimating the U.S. economic effects of the Panama Canal expansion is complicated. It should consider various domestic and foreign policies as well as global economic situations. To understand the overall impacts is to connect an economic impact model with trade pattern change stemming from the canal expansion because the economic impact can be understood as a main capital asset and easily transferred to number of jobs. Therefore, urban innovation that is understood as urban growth resulted from technical innovation in urban areas can be measured via an economic impact analysis. An issue is to be answered is how to measure the local impact due to the lack of a geographically disaggregate economic model in the U.S.

The simplest way to approach the problem is to apply a spatially disaggregate input–output (IO) model. The National Interstate Economic Model (NIEMO), which models all interstate trade relations among the U.S. states, is useful. As Park (2008) suggested, imports and exports require a separate IO model application and NIEMO's capability to estimate demand- and supply-side impacts is important to this type of study. Larger ships passing through the Canal will redirect sizable water-borne trade among U.S. ports, affecting the use of the other freight modes.

In this paper, we provide negative and positive estimates using secondary imports and exports data available from WISERTrade (www.wisertrade.org). First, we measured *reduced seaborne imports and exports to the West Coast Customs Districts (WCCD: Los Angeles Customs District, San Francisco Customs District, Columbia-Snake Customs*

District, and Seattle Customs District). The reduced port activities would occur in California, Oregon, and Washington, the states that receive foreign imports and send foreign exports. However, concurrent positive effects in the other states should be considered from increased imports and exports.

Studies on the panama canal expansion

In the emerging global economy, the primary driver of urban economic development has shifted from mass-production industries and low-skill service jobs to a sophisticated technology- and knowledge-based system of production and services. Therefore, international trade and investment will be key factors of urban and regional growth and crucial sources of local jobs and wealth. For improving or even maintaining their economic position, cities must provide the labor force, services, and infrastructure that allow locally based domestic and foreign-owned firms to participate more successfully in the international marketplace (Rondinelli et al., 1998).

Through its emergence as an important transshipment center for goods to/from Latin America and the Caribbean, Miami's economy can be revitalized. Over 50 % of U.S. trade with Caribbean countries and nearly 40 % of U.S. trade with Latin America transported through Miami (Jones, 1996). Los Angeles County and its surrounding areas attracted more than 140,000 jobs through the growth in business services, tourism, entertainment, and wholesaling largely attributed to international trade in 1995 (Kotkin, 1996). Also, Rondinelli et al. (1998) revealed that Detroit's economic recovery is being driven largely by the sharp increases in international sales of automobile industry, automotive suppliers, and other high-technology, high-value-added industries located in and around the city. Moreover, Urban (2007) identified the welfare of trade openness gains through a model that explains income divergence in a poverty trap regime, income convergence in a neoclassical regime, and a testable condition under which a country is depending on the degree of integration in product markets.

Recently, some research reports and papers have discussed plausible implications of the Panama Canal expansion. Rodrigue (2010) outlined the present Panama Canal functions and provided arguments for the expansion of the Canal. He categorized three main factors that may contribute to the expansion: macroeconomic factors (associated with changes in aggregate demand and the production structure), operational factors (related to freight distribution along the maritime shipping), and competitive factors (affecting other transport chains). However, predicting the economic impacts of the canal expansion is also a multidimensional function. As Knight (2008) summarized, it is necessary to consider the timing and location of the impacts on freight distribution to avoid possibly inconsistent economic assumptions associated with the Panama Canal expansion.

The timing and location complexity involves investment strategies planned in each port. A number of ports on the Atlantic and Gulf Coasts have initiated work on port expansion and modernization effort so as to ensure taking a greater proportion of global trade to their ports, responding to the Panama Canal expansion (CanagaRetna, 2013). More specifically, Boske and Harrison (2013) analyzed major aspects of trade between the U.S. and Asian countries as well as U.S.-Latin American trade, suggesting opportunities and challenges from canal expansion faced by Texas ports from competition of international trade. However, it is still unknown which states will be losers or winners in terms of economic impacts.

Another important research topic associated with canal expansion is to estimate environmental impacts. Using imports and exports projection data available from the Freight Analysis Framework (FAF) 3 database of the Federal Highway Administration, Bittner et al. (2012) estimated the potential impacts of canal expansion on greenhouse gas (GHG) emissions from trade between the U.S. and East and Southeast Asian countries. Focusing on GHG emissions changes and linking the size of ships and water-borne route distances, Corbett et al. (2012) probed more detailed the impacts: substitution to larger ships traversing the expanded Canal can reduce CO_2 emissions; however, longer water-borne route distances offset modal efficiencies in CO_2 emissions. It is not clear that diversion from the west coast ports to the south and east coast ports would reduce CO_2 emissions.

While all the studies reported recently, including environmental impact studies, did not address economic impacts due to many uncertainties involved, they do offer much useful information. For example, which states would expect a potential increase in water-bone shipping by the Panama Canal expansion? How can an IO model involve route-distance data by mode when addressing the economic impacts for various states which have different location from each port and time frame to be delivered? The next section explains how we modeled various complex questions which had not previously been addressed in economic impact analyses in the U.S.

Model and data

We applied the supply- and demand-side NIEMOs for the analysis and estimated the state-by-state and industry-by-industry economic impacts on the Panama Canal expansion for imports and exports. As input data for the application of the NIEMO models to trade diversion effects for the WCCD area, we collected and modified foreign imports and exports data available from WISERtrade, which is collected from the U.S. Census Bureau's Foreign Trade Division. We selected 15 Pacific Rim countries that traded with the WCCD ports. These include China, Japan, Republic of Korea, Hong Kong, Singapore, Australia, Taiwan, Malaysia, Philippines, Indonesia, New Zealand, Macao, Papua New Guinea, Brunei, and Thailand. Three-year average values of total imports and exports between 2010 and 2012 were calculated to mute the effects of outlier values. The second column in Table 1 shows the resulting imports and exports data by customs districts of the West Coast states.

We also derived transportation (each truck and rail mode) and warehousing margins for total foreign imports and exports, respectively. For this purpose, we used a use table from the National Input–output Accounts available from the Bureau of Economic Analysis (www.bea.gov). Multiplying these margins by the total imports and exports of each Customs District, we calculated the transportation and warehousing related activity values for foreign imports (upper table) and exports (lower table). The results are displayed in the third and fourth columns of Table 1 by each WCCD.

We allocated transportation and warehousing values of freight destined for other states. Based on the studies of Rodrigue (2010) and Knight (2008), we chose 12 states with seaports potentially impacted by the Panama Canal expansion. They are Alabama, Delaware, Florida, Georgia, Maryland, Massachusetts, New Jersey, New York,

Table 1 Selected foreign water-borne trade data to West Coast Customs Districts

Customs District	Total imports	Transportation cost		Warehousing cost
		Rail	Truck	
Los Angeles	169,518.14	4,059.60	10,954.29	4,109.48
San Francisco	23,733.60	568.37	1,533.67	575.35
Columbia-Snake	9,452.28	226.36	610.81	229.14
Seattle	28,831.68	690.46	1,863.11	698.94
Total	231,535.70	5,544.79	14,961.88	5,612.91
Customs District	Total exports	Transportation cost		Warehousing cost
		Rail	Truck	
Los Angeles	65,359.67	1,565.23	4223.55	1,584.46
San Francisco	13,461.79	322.38	869.90	326.34
Columbia-Snake	10,335.69	247.52	667.89	250.56
Seattle	17,784.75	425.91	1149.25	431.14
Total	106,941.91	2,561.03	6,910.61	2,592.50

Note: Imports and exports values are averaged from 2010 through 2012
Units: millions of dollars

Pennsylvania, South Carolina, Texas, and Virginia. To distribute transportation and warehousing amounts to these states, we applied the modal proportions of the Freight Analysis Framework version 3 (FAF^3). More specifically, we used the Origin–destination State Database for 2007 available from the U.S. Department of Transportation, Federal Highway Administration. Even though the FAF data have some limitation, the data source is still useful because it provides substantial freight movement data among U.S. states and major metropolitan areas by every major freight mode used for transport (Park et al., 2011).

Equation 1 explains the distribution process. From the 2007 FAF^3 database, we calculated the portion of foreign imports and exports that are distributed to the selected destination states from the WCCD ports via both truck and rail modes.

$$P\_IMP_i^j = \frac{IA\_TR_i^j}{TI_i}, \qquad P\_EXP_i^j = \frac{EA\_TR_i^j}{TE_i} \tag{1}$$

where
P_IMP = the portion of foreign imports,
P_EXP = the portion of foreign exports,
TI = total imports,
TE = total exports,
IA_TR = amount of foreign imports distributed by truck and rail modes,
EA_TR = amount of foreign exports distributed by truck and rail modes,
i = each origin state of the WCCD ports, and
j = each destination states.

Along with the portions allocated to each state and the transportation and warehousing costs of each WCCD suggested in Table 1, we estimated transportation and warehousing activities due to foreign imports and exports distributed to each state by truck and rail modes. Equations 2 and 3 are the bases for these estimated transportation and warehousing activity values; the estimated results are presented in Tables 2 and 3.

Table 2 Decreased transportation and warehousing activity values of foreign imports due to diversion from each West Coast Customs District state to various states

States	Los Angeles		San Francisco		Columbia-Snake		Seattle	
	TP value	WH value	TP value	WH value	TP value	WH value	TP value	WH value
AL	85.34	23.36	0.73	0.20	0.01	0.00	2.05	0.56
DE	2.05	0.56	0.13	0.04	0.00	0.00	0.84	0.23
FL	106.83	29.24	4.57	1.25	0.23	0.06	1.92	0.53
GA	193.28	52.90	5.82	1.59	0.41	0.11	9.14	2.50
MD	27.58	7.55	1.41	0.39	0.01	0.00	6.62	1.81
MA	40.68	11.13	6.88	1.88	0.03	0.01	3.24	0.89
NJ	468.05	128.11	7.25	1.99	5.49	1.50	19.67	5.38
NY	435.13	119.10	74.89	20.50	2.98	0.82	59.56	16.30
PA	120.97	33.11	6.77	1.85	0.82	0.23	20.01	5.48
SC	30.64	8.39	2.32	0.64	0.06	0.02	1.99	0.54
TX	909.63	248.98	32.57	8.91	92.09	25.20	9.28	2.54
VA	36.19	9.90	4.43	1.21	0.96	0.26	4.47	1.22
Total	2,456.36	672.33	147.78	40.45	103.09	28.22	138.77	37.98

Note: TP–Transportation; WH–Warehousing
Units: millions of dollars

$$TAV\_IMP_i^j = P\_IMP_i^j \times TPC_i, \qquad WAV\_IMP_i^j = P\_IMP_i^j \times WHC_i \tag{2}$$

$$TAV\_EXP_i^j = P\_EXP_i^j \times TPC_i, \qquad WAV\_EXP_i^j = P\_EXP_i^j \times WHC_i \tag{3}$$

where
TAV_IMP = transportation activity value of foreign imports,
WAV_IMP = warehousing activity value of foreign imports,
TAV_EXP = transportation activity value of foreign exports,
WAV_EXP = warehousing activity value of foreign exports,
TPC = transportation cost of each WCCD state, and
WHC = warehousing cost of each WCCD state.

Several assumptions are needed to estimate the change of transportation activity values in destination states by modal shift. First, the transportation distance by ship from each WCCD to destination states is assumed to be identical to the geographical distance between origin and destination states. Second, the freight that would arrive at destination states will travel to the nearby areas for 100 miles only using truck mode. We approximated the highway distance miles from the core city of each WCCD to the principal cities of destination states using *Google map*. Finally, we used dollar values of the imports and exports data; we also used the weight data to calculate the transportation values. We assumed these freight transport costs per ton-mile: water mode is $0.0074/ton-mile, truck mode $0.2619/ton-mile, and rail mode $0.0228/ton-mile, as Ballou (2004) suggested. The transportation activity values in destination states are shown in Tables 4 and 5.

Based on the National Interstate Economic Model (NIEMO) constructed by Park et al. (2007), we applied the demand-side and supply-side NIEMO models in this part of the study. Park (2007; 2008) and Park et al. (2008) elaborated both demand-side and

Table 3 Decreased transportation and warehousing activity values of foreign exports due to diversion from each West Coast Customs District state to various states

States	Los Angeles		San Francisco		Columbia-Snake		Seattle	
	TP value	WH value	TP value	WH value	TP value	WH value	TP value	WH value
AL	9.85	2.70	0.27	0.07	0.18	0.05	0.58	0.16
DE	7.53	2.06	0.35	0.09	0.00	0.00	1.41	0.39
FL	6.56	1.79	0.42	0.11	9.65	2.64	8.66	2.37
GA	11.21	3.07	1.47	0.40	3.21	0.88	1.14	0.31
MD	2.85	0.78	0.54	0.15	0.49	0.13	3.56	0.98
MA	4.71	1.29	0.44	0.12	1.52	0.42	1.84	0.50
NJ	22.68	6.21	1.94	0.53	8.02	2.20	4.35	1.19
NY	44.48	12.17	4.28	1.17	112.19	30.71	20.43	5.59
PA	19.84	5.43	1.29	0.35	27.48	7.52	4.80	1.31
SC	2.54	0.69	0.10	0.03	0.03	0.01	1.81	0.50
TX	378.22	103.52	16.78	4.59	3.78	1.03	2.76	0.76
VA	24.22	6.63	1.02	0.28	0.05	0.01	5.91	1.62
Total	534.68	146.35	28.89	7.91	166.59	45.60	57.24	15.67

Note: TP–Transportation; WH–Warehousing
Units: millions of dollars

supply-side NIEMO models, including empirical tests. Equations 4 and 5 suggest the structure of demand-side and supply-side NIEMO models in a matrix form:

$$X^{O} = \left(I - C^{D}N^{D}\right)^{-1}F \tag{4}$$

where

X^{d} = the total output column vector for s (=1, …, 47) USC Sectors and r (=1, …,52) regions,

$C^{D} = C\left(\widehat{C}_{j}^{s}\right)^{-1}$ and $\widehat{C}_{j}^{s}$ is a sr × sr diagonal matrix of 1 × sr row vector,

$C_{j}^{s} = \sum_{i} C_{ij}{}^{s}$ and C_{ij}^{s} is a trade flows for USC sector s between regions i and j,

$N^{D} = Z\left(\widehat{X}^{I}\right)^{-1}$ and $\widehat{X}^{I}$ is a sr × sr block diagonal matrix of vector X^{I},

X^{I} = the total input row vector,

Z = the block diagonal matrix of direct technical flows between industries, and

F = a row vector of region specific final demand.

$$X^{I} = A\left(I - N^{S}C^{S}\right)^{-1} \tag{5}$$

where

X^{I} = the total input row vector for s (=1, …, 47) USC sectors and r (=1, …,52) regions,

A = a row vector of region specific value added factors,

$N^{S} = \left(\widehat{X}^{O}\right)^{-1}Z$ and $\widehat{X}^{O}$ is a sr × sr block diagonal matrix of vector X^{O},

X^{O} = the total output column vector,

Z = the block diagonal matrix of direct technical flows between industries, and

$C^{S} = \left(\widehat{C}_{j}^{s}\right)^{-1}C$ and $\widehat{C}_{j}^{s}$ is a sr × sr diagonal matrix of 1 × sr row vector,

$C_{j}^{s} = \sum_{i} C_{ij}{}^{s}$ and C_{ij}^{s} is a trade flows for USC Sector s between regions i and j.

Table 4 Weight and transportation activity values of foreign imports diverted from each Customs District to various states

States	Los Angeles			San Francisco		
	Distance	Weight	TP_delta	Distance	Weight	TP_delta
AL	2,200	152,231	81.25	2,400	2,119	0.84
DE	2,800	3,663	2.51	3,000	378	0.28
FL	2,700	190,575	125.64	3,000	13,325	9.82
GA	2,500	344,791	203.94	2,800	16,977	11.65
MD	2,700	49,196	31.94	2,900	4,109	2.89
MA	3,000	72,568	50.98	3,200	20,061	15.81
NJ	2,900	834,941	587.25	3,000	21,139	14.24
NY	2,900	776,213	539.51	3,000	218,287	160.89
PA	2,900	215,800	152.37	3,000	19,746	14.52
SC	2,600	54,659	34.74	2,800	6,767	4.64
TX	1,600	1,622,673	586.49	1,900	94,917	42.91
VA	2,800	64,552	43.23	3,000	12,898	6.73
Average	2,633	312,990	203.32	2,833	30,766	23.77
Total	31,600	4,381,862	2,439.84	34,000	430,722	285.22
Unit	mile	ton	$ million	Mile	ton	$ million
States	Columbia-Snake			Seattle		
	Distance	Weight	TP_delta	Distance	Weight	TP_delta
AL	2,600	35	0.022	2,700	3,911	1.66
DE	2,900	4	0.003	2,900	1,602	1.14
FL	3,300	833	0.678	3,400	3,671	3.08
GA	2,900	1,458	1.038	3,000	17,441	12.86
MD	2,800	49	0.033	2,800	12,635	8.67
MA	3,100	113	0.071	3,000	6,174	4.28
NJ	2,900	19,683	13.615	2,900	37,534	26.67
NY	2,900	10,676	7.541	2,900	113,663	80.78
PA	2,900	2,949	2.085	2,900	38,184	27.05
SC	2,900	217	0.154	3,000	3,796	2.80
TX	2,300	330,151	183.960	2,300	17,702	9.34
VA	3,000	3,446	2.358	3,000	8,526	6.29
Average	2,875	26,401	17.630	2,900	18,917	15.38
Total	34,500	369,614	211.559	34,800	264,840	184.61
Unit	mile	ton	$ million	Mile	ton	$ million

Note: TP_delta = Baseline transportation activity values (via truck and rail modes) – Alternative transportation activity values (via water and truck modes)

The USC Sector definitions are found in Table 6. It comprises of 29 commodity and 18 service sectors, resulting in total 47 sectors. These sectors are transferable to other U.S. economic sector systems such as The North American Industry Classification System, the Standard Industrial Classification, the Standard Classification Transportable Goods, and so on. Many studies have used this USC Sector system since 2006 (see some recent examples in Richardson et al., 2014; Cho et al., 2015; Park and Richardson, 2014).

Table 5 Weight and transportation activity values of foreign exports diverted from each Customs District to various states

States	Los Angeles			San Francisco		
	Distance	Weight	TP_delta	Distance	Weight	TP_delta
AL	2,200	67,512	24.18	2,400	2,658	1.32
DE	2,800	51,589	35.41	3,000	3,444	0.87
FL	2,700	44,935	25.40	3,000	4,160	3.07
GA	2,500	76,848	43.78	2,800	14,644	8.97
MD	2,700	19,554	12.42	2,900	5,349	3.81
MA	3,000	32,247	23.78	3,200	4,374	3.45
NJ	2,900	155,447	96.57	3,000	19,296	13.96
NY	2,900	304,856	216.81	3,000	42,669	31.46
PA	2,900	136,006	86.28	3,000	12,888	5.73
SC	2,600	17,385	9.92	2,800	1,002	0.55
TX	1,600	2,592,157	819.15	1,900	167,152	53.81
VA	2,800	165,979	113.93	3,000	10,154	7.49
Average	2,633	305,376	125.64	2,833	23,982	11.21
Total	31,600	3,664,514	1,507.63	34,000	287,790	134.49
Unit	mile	ton	$ million	Mile	ton	$ million
States	Columbia-Snake			Seattle		
	Distance	Weight	TP_delta	Distance	Weight	TP_delta
AL	2,600	5,516	3.50	2,700	8,767	5.79
DE	2,900	3	0.00	2,900	21,422	15.25
FL	3,300	298,973	243.26	3,400	131,776	110.57
GA	2,900	99,489	70.82	3,000	17,388	12.82
MD	2,800	15,205	10.44	2,800	54,214	37.21
MA	3,100	47,198	36.00	3,000	28,017	20.64
NJ	2,900	248,577	101.87	2,900	66,140	45.85
NY	2,900	3,477,017	2,475.15	2,900	310,883	221.28
PA	2,900	851,617	605.58	2,900	73,051	50.87
SC	2,900	884	0.63	3,000	27,597	20.34
TX	2,300	117,059	4.96	2,300	41,997	18.30
VA	3,000	1,568	1.16	3,000	89,962	66.33
Average	2,875	430,259	296.11	2,900	72,601	52.11
Total	34,500	5,163,105	3,553.37	34,800	871,215	625.26
Unit	mile	ton	$ million	Mile	ton	$ million

Note: TP_delta = Baseline transportation activity values (via truck and rail modes) – Alternative transportation activity values (via water and truck modes)

Results

For an impact analysis of Panama Canal expansion, we assumed: foreign imports and exports that currently arrive and leave in the various WCCD ports to be transported to the other South and East Coast states via truck and rail modes would be directly shipped to these states through the deepened Panama Canal. Therefore, transportation and warehousing activity values of foreign imports and exports presented in Tables 2 and 3 are assumed to decrease in the West Coast states. To address new transportation and warehousing activities that occur in each state designated, we measured the

Table 6 Definitions for USC Sector system

USC sector	Description
USC01	Live animals and live fish & Meat, fish, seafood, and their preparations
USC02	Cereal grains & Other agricultural products except for Animal Feed
USC03	Animal feed and products of animal origin, n.e.c.
USC04	Milled grain products and preparations, and bakery products
USC05	Other prepared foodstuffs and fats and oils
USC06	Alcoholic beverages
USC07	Tobacco products
USC08	Nonmetallic minerals (Monumental or building stone, Natural sands, Gravel and crushed stone, n.e.c.)
USC09	Metallic ores and concentrates
USC10	Coal and petroleum products (Coal and Fuel oils, n.e.c.)
USC11	Basic chemicals
USC12	Pharmaceutical products
USC13	Fertilizers
USC14	Chemical products and preparations, n.e.c.
USC15	Plastics and rubber
USC16	Logs and other wood in the rough & Wood products
USC17	Pulp, newsprint, paper, and paperboard & Paper or paperboard articles
USC18	Printed products
USC19	Textiles, leather, and articles of textiles or leather
USC20	Nonmetallic mineral products
USC21	Base metal in primary or semi-finished forms and in finished basic shapes
USC22	Articles of base metal
USC23	Machinery
USC24	Electronic and other electrical equipment and components, and office equipment
USC25	Motorized and other vehicles (including parts)
USC26	Transportation equipment, n.e.c.
USC27	Precision instruments and apparatus
USC28	Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs
USC29	Miscellaneous manufactured products, Scrap, Mixed freight, and Commodity unknown
USC30	Utility
USC31	Construction
USC32	Wholesale Trade
USC33	Transportation
USC34	Postal and Warehousing
USC35	Retail Trade
USC36	Broadcasting and information services
USC37	Finance and Insurance
USC38	Real estate and rental and leasing
USC39	Professional, Scientific, and Technical services
USC40	Management of companies and enterprises
USC41	Administrative support and waste management
USC42	Education Services
USC43	Health Care and Social Assistances

Table 6 Definitions for USC Sector system *(Continued)*

USC44	Arts, Entertainment, and Recreation
USC45	Accommodation and Food services
USC46	Public administration
USC47	Other services except public administration

difference between baseline transportation and alternative transportation modes. This accounts for transportation activity benefits in other South and East Coast states. We also allocated the decreased warehousing activity values to other destination states as increases, assuming the warehousing margin is identical there. Note that we did not account for any other transportation mode cost changes in the short-term.

Therefore, we separately estimated the reduced impacts of transportation and warehousing activities for foreign trade in the West Coast states and the increased impacts in the other states. Both the demand- and supply-side NIEMO models were applied. Because "direct impact" refers to the initial economic impact experienced in each sector in each state, it is the change of foreign imports and exports in the states presented in Tables 2 and 3 relating to the Panama Canal expansion. "Indirect impact" indicates the economic impact arising due to inter-industry linkages; this is measured via the inverse coefficients of the NIEMO models. A Type I multiplier describes the sum of direct and indirect impacts relative to direct impact.

The summary results of the reduced impacts in the West Coast states are presented in Fig. 1. The reduced impacts of transportation and warehousing values negatively affected the national economy. We show the top three impacted states and top ten USC Sectors in Fig. 1. The upper left figure presents: the most affected state was California ($-4926 million, 85 %); Washington ($-296 million, 5.1 %) would be second, and Oregon ($-212 million, 3.7 %) third for the reduction of transportation and warehousing values of foreign imports in California, Oregon, and Washington by $3 billion, $0.1 billion, and $0.2 billion, respectively. In the case of foreign exports, the economic losses of California, Oregon, and Washington were estimated $1190 million (64.1 %), $348 million (18.7 %), and $133 million (7.2 %), based on the direct impacts of $700 million, $200 million, and $70 million, respectively.

For the impacts on the top ten USC Sectors of foreign imports, the total economic losses of USC Sectors 33 (Transportation), 34 (Postal and Warehousing), and 30 (Utility) are $3109 (53.7 %), $818 (14.1 %), and $144 (2.5 %) million, respectively. The Type I multiplier in this case was 1.599. In order for USC sectors 33, 34, and 10 (Coal and petroleum products), the losses for foreign exports are sizable as $916 (49.3 %), $234 (12.6 %), and $111 (6.0 %) million, respectively. The Type I multiplier for the foreign exports case was 1.851.

The total positive gains stemming from the shift of transportation modes and new warehousing activities for foreign imports in the other states were $6304 million; those for foreign exports were $9218 million. The impacts in the 12 U.S. South and East Coast states and the top ten USC sectors are presented in Fig. 2. Individual economic gains from the shift of foreign imports were greatest in Texas as $1717 million (27.2 %), and New York ($1413 million, 22.4 %) and New Jersey ($1140 million, 18.1 %) were ranked the second and third benefited among 12 states. The shift gains for foreign

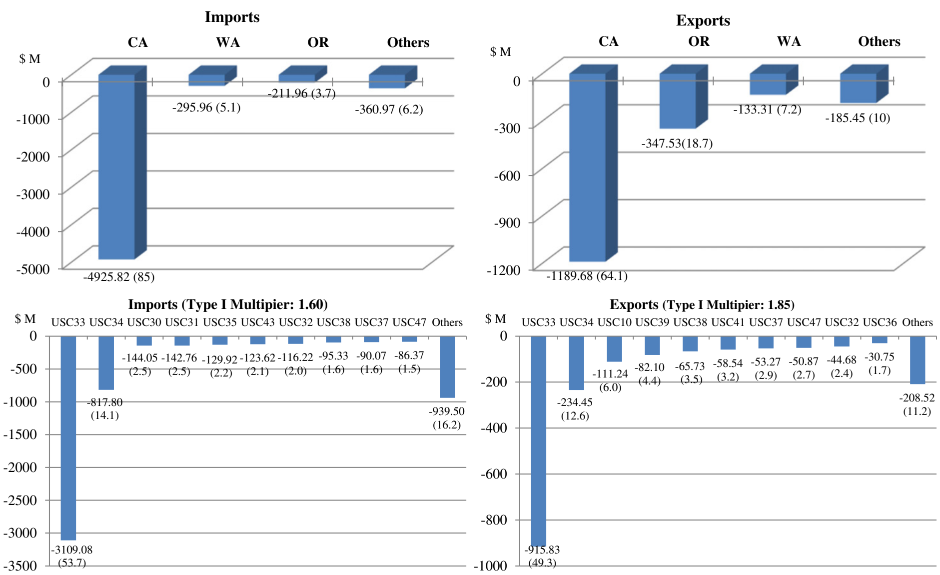

Fig. 1 Impacts of reduced transportation and warehousing activities in the West Coast states for top three states and by top ten USC Sectors. Note: 1. Negative sign indicates economic losses. 2. The value in parenthesis is the percentage to total impacts. 3. Others in upper two graphs: 47 states, D.C. and the rest of word excluding top three states. 4. Others in lower two graphs: 37 other USC Sectors excluding the top ten sectors

exports were considerable in New York ($4902 million, 42.3 %), Texas ($1909 million, 16.5 %), and Pennsylvania ($1387 million, 12.0 %).

As transportation modes changed and warehousing activity of foreign imports to 12 states increased, the gain to USC Sector 33 ($3467 million, 55 %) is the highest as expected, and USC Sectors 34 ($821 million, 13 %) and 43 (Health Care and Social Assistances, $163 million, 2.6 %) follow. The Type I multiplier in this increased activity case was 1.616. The gains for foreign exports were high in USC Sectors 33 ($6668 million, 57.6 %), 10 ($664 million, 5.7 %), and 39 (Professional, Scientific, and Technical services, $564 million, 4.9 %); The Type I multiplier for the foreign exports case was 1.918.

Conclusions and discussion

The Panama Canal expansion presents many complex issues for analysts attempting to estimate the various U.S. economic effects. There are simultaneous responses in the impacted as well as other states. Among the challenges are the problem of developing an appropriate economic model and adapting plausible scenarios to the economic model developed. We attempted to face these challenges and understand economic effects in the change of international trade pattern and activities of logistics industry in this paper.

Our approach was to apply NIEMO's supply- and demand-side interstate input–output models. We subtracted Pacific Rim imports and exports destined for the West Coast states which cover the ports in the Customs Districts of Los Angeles, San Francisco, Columbia-Snake, and Seattle and added (diverted) these volumes to various competing U.S. seaports. The results presented are the net multiplier effects of both phenomena. According to the total reduction of transportation and warehousing values for foreign imports in the West Coast ports by $3.3 billion, the total negative impacts

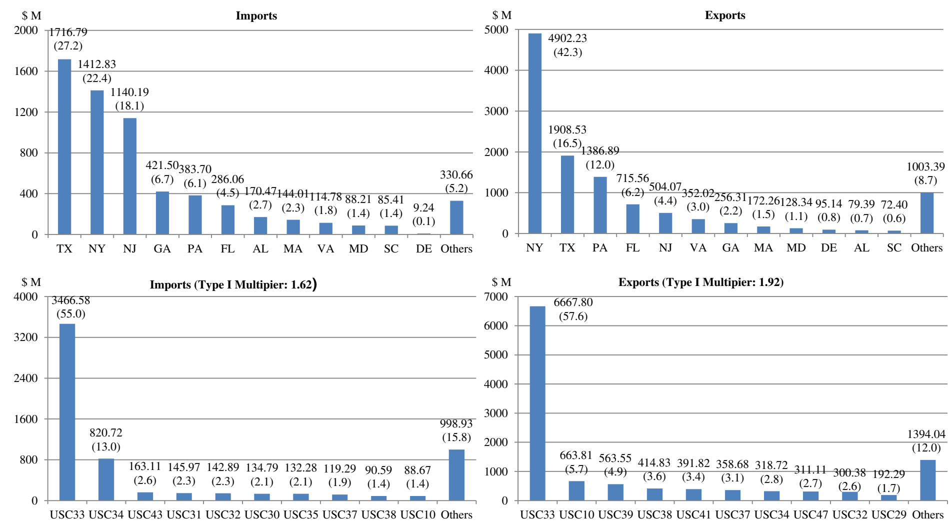

Fig. 2 Positive impacts of transportation mode change and warehousing activity increase in other states for 12 alternate destination states and top ten USC Sectors. Note: 1. Positive sign indicates economic gains. 2. The value in parenthesis is the percentage to total impacts. 3. Others in upper two graphs: 38 states, D.C. and the rest of word excluding 12 destination states. 4. Others in lower two graphs: 37 other USC sectors excluding the top ten sectors

were estimated to be $5.8 billion; those for foreign exports were $1.6 billion. This is similar to Park's (2008) finding that foreign imports in the West Coast region account for total trade in the U.S. about four times of total foreign exports. Interestingly, total positive gains from the shift of transportation modes and new warehousing activities for foreign exports in the 12 South and East Coast states accounted for $9.2 billion, exceeding the total gains of $6.3 billion for foreign imports. New York and Texas would be the most benefited states in the nation. These findings will contribute to understanding how the Panama Canal expansion may affect changes in urban growth in the U.S. and future technical innovations in open economy, depending on new investment in various seaports in East Coast and its ripple impacts on other major U.S. cities.

However, it should be mentioned that the economic modeling approach adopted in this study has various limitations. First, modeling economic impacts is only useful to address short term effects. This is because an uncountable number of prices adjust in the long term and analyzing all of these economic impacts is inconceivable. Even though we applied demand-side as well as supply-side impacts for a short term as both foreign imports and exports to various U.S. ports are affected, this study did not account for how the states located in the U.S. Midwest region (Indiana, Illinois, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) and the Mountain Division of West region (Arizona, Colorado, Idaho, New Mexico, Montana, Utah, Nevada, and Wyoming) would change their entry points for foreign trade. The states' behavioral changes depend on their decision process to minimize the multi-modal delivery costs. Also, it would model the U.S. port investment strategies which would affect the assumption of the 100-mile highway distance assumed in each destination states. As a major recipient port in the U.S., for example, Charleston may offer lower delivery costs to other destination cities than other adjacent states, possibly delivered via rail mode. These factors make the modeling task more complex and a new type of decision process approach would have to be combined with the current NIEMO approach.

Despite the limitations described above, this study accounted for various other transportation activity changes associated with importing and exporting weights, additionally to the change of transportation and warehousing activity values for foreign imports and exports. We expect to develop various smaller diversion scenarios; we only assumed a one-hundred percent diversion of foreign imports and exports arriving or leaving at the West Coast region, which is delivered to other states out of the region. Diverse diversion scenarios by scaling down will be more useful to figure out the future of the region with a minimal effort because NIEMO is linear. Furthermore, it will be useful to model local freight movements, for example, in Southern California by applying a local freight model developed by Giuliano et al. (2010).

For the next research progress to improve the limitations conducted in this study, we will consider the following points. First of all, various policy implications about recovery plans stemming from the possible losses of the West Coast ports should be addressed. Second, concerning the U.S. trade diversion derived by the canal expansion, we will develop an econometric model that captures several key relevant factors and measure the pure effect of Panama Canal expansion on the change of the U.S. trade. Finally, because the U.S. trade change at the West Coast seaports is also affected by demand side factors of foreign countries simultaneously with the canal expansion, an elaborated model that combines this empirical pattern change in demand with the current economic impact model needs to be developed.

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Authors' contributions
CP participated in the design of the study and performed the statistical analysis. Also, CP drafted the manuscript. JY conceived of the study and participated in its design, coordination, and editing the manuscript. Both authors read and approved the final manuscript.

Competing interest
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