# Impact of Panama Canal Expansion

**Bachelor of Technology**

*in*

## Civil Engineering

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# Abstract

The expanded Panama Canal opened on June 26, 2016. This expansion is the third set of locks that enabled the canal to double its capacity through the addition of new traffic lanes, which allowed neo-Panamax and some post-Panamax vessels to transit across the canal. The widening of the canal has increased maritime traffic within Latin America and the Caribbean (LAC). Major ports in the regions have made huge investments in port expansion and infrastructural development to accommodate neo-Panamax vessels. In this study, we investigated the impact of the Panama Canal expansion (PCE) on the Latin America and the Caribbean (LAC) ports by using the Difference in Difference (DID) method. This impact was evaluated for 100 major and regular ports within the three sub-regions of LAC, namely Caribbean, Central, and South America, before and after the treatment effect, that is, the PCE. The findings from the model revealed that the average container port throughput (TEUs) for the treated ports (DTrp) was more than that of the controlled ports (CONTp) with transshipment hub, Central America, and South America having 2012%, and 34% growth, respectively, since the PCE (the treatment) except for the Caribbean ports (DTrp), which experienced losses of 8% within the LAC region from 2010 to 2019.
***Keywords:*** Maritime traffic, Panama Canal, Difference in differences (DID), NeoPanamax

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CHAPTER 1

# Introduction

## 1.1 Introduction

Panama Canal, a lock-type canal, owned and administered by the Republic of Panama, that connects the Atlantic and Pacific oceans through the narrow Isthmus of Panama. The length of the Panama Canal from shoreline to shoreline is about 40 miles (65 km) and from deep water in the Atlantic (more specifically, the Caribbean Sea) to deep water in the Pacific about 50 miles (82 km). The canal, which was completed in August 1914, is one of the two most strategic artificial waterways in the world, the other being the Suez Canal. Ships sailing between the east and west coasts of the United States, which otherwise would be obliged to round Cape Horn in South America, shorten their voyage by about 8,000 nautical miles (15,000 km) by using the canal. Savings of up to 3,500 nautical miles (6,500 km) are also made on voyages between one coast of North America and ports on the other side of South America. Ships sailing between Europe and East Asia or Australia can save as much as 2,000 nautical miles (3,700 km) by using the canal.

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

Figure 1.1: Construction Of the Canal

chains, and logistics. According to CanagaRetna [1](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 toward the urban innovation process. The urban innovation process is reached by deepening capital and increasing in human resources through technologically innovative progress and agglomeration economies in urban areas. Urban cities are rapidly experiencing the 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 incorporating the city's 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 the per-capita income of residents and laborers in urban cities.

Investigating the relationship between the expansion of the Panama Canal and its state and regional economic impacts that will be potentially affected within the U.S. can provide various policy insights into urban growth and technical innovations in the U.S. For example, while West Coast cities may have inverse experiences, an 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 the transportation industry draw various discussions in technological innovations. Through this study, stakeholders of the canal expansion and policymakers will get the basic grounds of their decision-making process of investment adapted to globalization and the new technical innovation process needed to expand their port capacities.

CHAPTER 2

# Literature Review

## 2.1 Panama Canal Impact on the Regions

Undoubtedly, the expansion of the Panama Canal has impacted both North America and LAC regions. It has allowed the transit of mega-ships such as Neo and Post Panamax vessels to increase container throughput (TEUs) and Cargo tonnage at ports within the region. PCE has increased competition among important transshipment ports in Panama, Brazil, Jamaica, Mexico, the Bahamas, and the Dominican Republic (Rodrigue and Ashar 2016). Most of these countries have made considerable investments in port expansion, dredging, and logistics centers to accommodate and attract mega-ships to their shores.

Using an impact evaluation method was necessary to assess the impact of the expansion within this region. Hawkins et al. (2015, pp. 26) define impact as a longer-term result generated by policy decisions, often through intervention, project, or programs. The PCE project has influenced the Americas' subprojects, including the LAC region, in dredging and port infrastructural improvements (Link 2015). Rodrigue and Ashar (2016), UNCTAD (2014), and Singh et al. (2015) stated that the advent of Mega-ships through the now expanded canal would influence greater transshipment yield and container traffic among transshipment ports. On the other hand, Marle (2016) alluded that the PCE has raised fears that the LAC container terminals were overcapacity due to port infrastructure and usage. Gooley (2018) also stated that the Port of Panama (ACP) indicated that some carriers shift from mega-ships due to high operating costs per container. He further stated that International Maritime Organization (IMO) mandated on January 1, 2020, that the use of low sulfur fuel could see more ships slow steaming to reduce fuel consumption by using the longer Suez route instead of shorter transits via Panama.

The expansion of the Panama Canal has impacted ports in the East and Gulf ports of the USA. According to Bhadury (2016) and Park et al. (2020), the PCE has increased cargo traffic flow from the West Coast to the East Coast, decreasing transportation costs and increasing transit time. This impact will enable more cargo traffic to transit the Panama Canal and increase transshipment activities within the Caribbean region. Nicholson and Boxill (2017) strongly believe that if most of the US East Coast ports become "ship ready" by improving port infrastructure such as longer quays, bigger cranes to accommodate 18 to 22 containers, more storage space for containers, deeper channels, and berth, and higher bridges, then most Caribbean ports could see a reduction in transshipment activities. For example, ports such as Baltimore, Charleston, Miami, Philadelphia, and Virginia have official increases in container throughput (TEUs) due to ships transiting the expanded Panama Canal.

## 2.2 The Advent of Mega-Ships to LAC (Economy of Scale)

The Panama Canal is one of the main passages connecting the Pacific and Atlantic oceans, accounting for approximately 6% of global trade (FreightWaves 2020). According to the Panama Canal Authority [6](2019), in 2018, the United States, China, Japan, Mexico, and Colombia were the primary Canal users, with the United States accounting for 68.3% of the total cargo transiting the canal. This expansion has opened the doors to Neo-Panamax and Post-Panamax vessels, impacting cargo throughput volumes for intraregional ports, US Gulf, and East Coast ports.

Figure 1 shows that After the expansion in 2016, there was a surge in cargo tonnage through the expanded canal, while no significant changes were observed in the number of transits (Rodrigue 2020). Several authors supported the positive effects of mega-ships on international and regional ports. Merk (2018) stated that doubling the maximum container ship size has reduced total vessel cost per transported container by roughly a third over the last decade. OECD (2015) supported his view, stating that con-

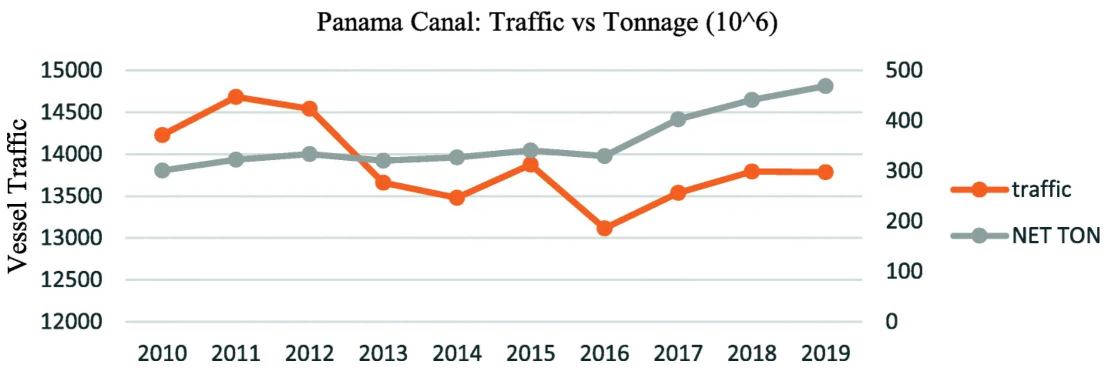


Figure 2.1: Panama Canal Traffic and Traffic vs. Net Tonnage comparison for the period 2010–2018. Source: Panama Canal Authority (2019)

tainerization has contributed to decreased transportation costs. On the other hand, Lim (2011) studied the economies of scale in container shipping. The findings revealed that although huge container ships will produce economies of scale and significantly reduce the slot cost in container trade to which the ship is assigned, the industry may never make an adequate return because of over-demand. Therefore, the benefits of economies of scale will diminish over time. Kapoor [2](2016) studied the economics of scale for mega container vessels. The report revealed four (4) significant findings; (1) that the economies of scale diminish for vessel sizes beyond 18,000 TEUs; (2) that terminals will incur significant capital expenditure to handle larger vessel sizes and require terminal yard to increase by a third in order to avoid congestion; (3) terminal will have to increase productivity to compile with the increase in vessel size and (4) vessel upsizing risk the results of no significant cost benefit that will furthermore contribute to higher supply chain risk as volumes will be concentrated on fewer ships that will compile environmental issue of dredging deeper channels. An overview of the authors revealed that vessels were getting larger because of the theory of economy of scale. However, the effects of diminishing 'scale of economic' of mega-ships may not be necessarily beneficial for some regional ports.

The impact of the PCE on the US ports and LAC region has been studied by several authors such as Rodrigue and Ashar (2016), Singh et al. (2015), Bhadury (2016), and Park et al. (2020). They strongly agreed that PCE had impacted port infrastructure improvement within both regions. Pham et al. (2018), Rodrigue (2020), and Fan and Gu [4](2019) studies agreed that PCE has influenced liner shipping, trading routes, and cost savings for LAC and US ports on both the East and West coasts. Several authors, such as Merk (2018), Lim (2011), Kapoor (2016), and Rodrigue (2020), strongly agreed that the advent of mega-ships had impacted container throughput and cargo tonnage. On the other hand, few authors address the causal effects of PCE on the LAC regional ports before and after the expansion to determine its overall impact. Several methodology applications such as port choice, route planning, adaptive port planning, and Cost-base analysis models were used to assess the effect of this expansion on global and US ports. However, limited authors use impact evaluation methods to determine the causal impact of the PCE as an intervention within the LAC. This research gap will be addressed using impact evaluation; Difference in Difference (DID), to assess the PCE implications for all three LAC sub-regions and transshipment ports.

CHAPTER 3

# Method and Data

## 3.1 Competition Among Ports on the US East Coast for Cargo

The PCE has influenced the development of ports within the US, especially on the East Coast, regarding traffic patterns, infrastructural upgrades, and intermodal connectivity (Kendrick 2020). The anticipated projection for improvement in the shipping industry on the East Coast and the Gulf of Mexico has increased container throughput growth (TEUs). This growth was because more container ships from Asia would directly access East Coast markets (Morley and Ashe 2019). Table 1 shows the container throughput for five major ports on the East and Gulf coasts. In 2019, TEUs growth percentage, the port of New York and New Jersey (4%), the Port of Houston (11%), the Port of Miami (3%), the Port of Charleston (5%), and the Port of Savannah (6%). These improvements in East Coast and Gulf of Mexico ports attract more container traffic at the expense of ports within the Caribbean and some parts of the Americas (Morley and Ashe 2019).

The top 5 major ports within the region have experienced small increases in TEUs except for the port of Balboa. The improvement of US East and Gulf ports has increased competition among East Coast for cargo, impacting transshipment volumes within the LAC region. Table 2 shows the top five ports within the LAC region regarding the annual percentage growth in TEUs from 2010 to 2019. Among five other transshipment hubs, these ports represent approximately 84.1The TEU growth (%) for port of

| Year | Port of NY/NJ | Port of Houston | Port of Miami | Port of Charleston | Port of Savannah |
|---|---|---|---|---|---|
| 2010 | 16% | 1% | 5% | 16% | 25% |
| 2011 | 4% | 3% | 7% | 1% | 4% |
| 2012 | 0% | 3% | 0% | 10% | 1% |
| 2013 | -1% | 1% | -1% | 6% | 2% |
| 2014 | 6% | 0% | -3% | 12% | 10% |
| 2015 | -10% | 9% | 15% | 10% | 12% |
| 2016 | -2% | 2% | 2% | 1% | -2% |
| 2017 | 7% | 13% | 0% | 9% | 11% |
| 2018 | 7% | 10% | 6% | 6% | 8% |
| 2019 | 4% | 11% | 11% | 5% | 6% |

Table 3.1: 1 Top 5 US East and Gulf of Mexico Ports, TEU annual Percentage Growth (%)

Colon (1%), Port of Santos (2%), Manzanillo (0%), Cartagena (2%) and Balboa (15%). The comparison of container throughput (TEU) growth shown in Fig. 2, the percentage of US East and Gulf ports vs. top 5 LAC ports, shows that in 2019, the top 5 East coast ports recorded more percentage growth than LAC ports.

## 3.2 The Difference in Difference (DID)

An impact evaluation provides evidence about the impacts that have been produced or the impacts that are expected to be produced[9] (Hawkins et al. 2015). The choice of methods and designs for evaluating policies, projects, and programs, can be difficult tobe evaluated and may come with unique challenges (Hawkins et al. 2015). White and Sabarural (2014) stated that a quasi-experimental approach is an empirical intervention study used to estimate an intervention's causal impact or test causal hypotheses. The most frequently used quasi-experiment approach is Differences in Differences (DID), based on a combination of before - after and treatment - control group comparisons (Fredriksson and Oliveira 2019; World Bank 2021). Several authors used the Difference in Difference (DID) approach to assess government policies and programs' impact and their effectiveness. Card and Krueger (1994) studied the impact of the increase in the minimum wage on employment for fast-food restaurants in New Jersey, the US, and Eastern Pennsylvania before and after the increase. The findings revealed that by using DID. There was no indication that an increase in the minimum wage reduced employment. Qiu and He (2017) researched the impact of the Green Traffic Policy on air quality in China. They concluded that the pilot program was effective in reducing the annual concentration

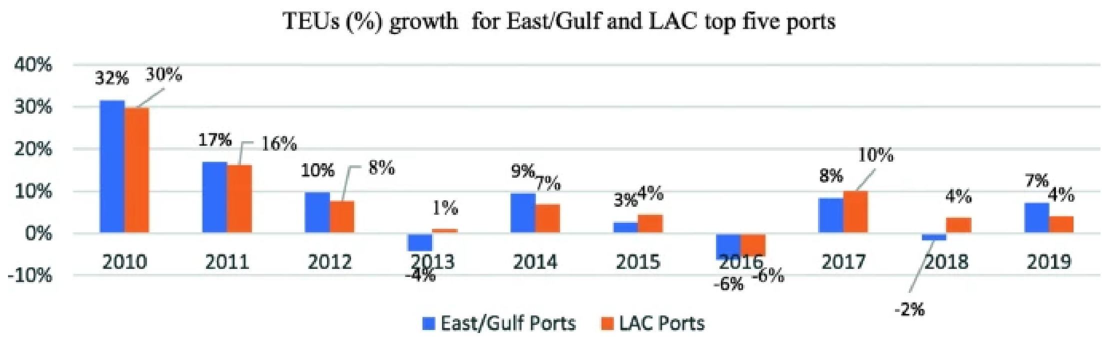


Figure 3.1: The top five regional ports for both East/Gulf and LAC TEUs growth (%). Source: Own Elaboration

of pollutants. However, although the DID method is popular among various research fields, it is not without limitations. Bertrand et al.[3] (2003) mention that the great appeal for DID estimation comes from its simplicity and potential to circumvent many of the endogeneity problems that arise when comparing heterogeneous groups. Wing et al. (2018) supported Bertrand et al. (2003) view, they stated that the Difference in Difference (DID) design was not an ideal alternative for randomized experiments, but it often signifies as a viable way to learn about causal relationships. They further concluded that multiple quasi-experimental techniques might be an essential support for the Difference in Difference (DID) approach.

## 3.3 Parallel Trend Assumption (PTA)

All the assumptions of the Ordinary Least Square Model apply equally to the Difference in Difference (DID). Many assumptions, such as Parallel Trend Assumption (PTA), exchangeabilitychangeability, and Stable Unit Treatment Value Assumption (SUTVA), must hold to ensure the models' internal validity (Columbia Public Health 2020; Mckenzie 2021). Two of the most popular assumptions are Parallel Trend Assumption (PTA) and Stable Unit Treatment Value Assumption (SUTVA). According to Lechner (2011), SUTVA indicates that there should be no spill-over influences fluences between the treatment and control groups, as the treatment effect would then not be identified. The Parallel Trend Assumption (PTA) is the most critical of the Miller and Hyodo Journal of Shipping and Trade (2021) 6:8 Page 8 of 23 above assumptions to ensure the DID Model's internal validity and may be difficult to execute because it requires that the difference between the treatment and control groups be constant over time [5](Lechner 2011). The assumption is fundamentally untestedable because the treatment group is only observed as treated (Fredriksson and Oliveira 2019). "One can lend support to the assumption, however, using several periods of pre-reform data, showing that the treatment and control groups exhibit a similar pattern in pre-reform periods" These studies focused on using the DID approach for assessing treatment effects on policies and programs in the sectors of education, finance, public sector economics, healthcare, sales, and marketing. This research will focus on using the DID model for the Maritime Industry to assess the PCE impact on TEUs growth among ports in Latin America and the Caribbean regions (LAC).

CHAPTER 4

# Result

The results on the impact of the Panama Canal expansion (PCE) on LAC regional ports were conducted using the traditional Difference in Difference (DID) equation – i.e., exactly the specification described.

TEUs= $\alpha + \beta TreatmentPort + \gamma PostTreatment + \delta(TreatmentPortPosttreatment) + \varepsilon i$

Where intercept, TreatmentPort, PostTreatment, and Diff-in-Diff were all statistically significant at 1%, 5%, and 10% levels as shown in Table 6. The regression results for transshipment, Caribbean, Central America, and South America ports, r values were 0.41, 0.87, 0.83, and 0.31. Table 7, a statistical description of three (3) sub-regional and transshipment hubs of 100 ports from the period 2010 to 2019; the coefficient for the treatment (DTrp) and Control (CONTp) ports, were all statistically significant at 1% level. For transshipment hub ports, the estimated coefficient =0.077 (statistically significant at the 10% level) and indicates that the average container port throughput (TEU) of the DTrp increased by 20% (170,000 TEUs) more than that of non-transshipment ports within the LAC region since the PCE. For the Caribbean region, the estimated coefficient =0.026 (statistically significant at the 5% level) and indicates that the average container throughput (TEU) for Treatment Ports (DTrp) decreased by 8% (140,000 TEUs) less than control ports (CONTp). For the Central American region, the estimated coefficient =0.087 (statistically significant at the

10% level) and an average container throughput (TEU) increase of 12% (280,000 TEUs) than control ports (CONTp) since the PCE. For ports in the South American region, =0.095 (statistically significant at the 10% level) and indicates 34.4% (260,000 TEUs) than control ports (CONTp) since the PCE.

The Parallel Trend Assumption (PTA) was used to test the model's validity to ensure no biased estimation of causal effects [7](Fredriksson and Oliveira 2019). A validity check compares changes to the treatment and comparison group's changes before and after the program (Columbia Public Health 2020; Mckenzie 2021). Table 5 was used to classify the LAC ports into treatment (DTrp) and control (CONTp) groups from 2010 to 2019. Pre-treatment period "Before" and "After" the PCE. Fig. 7 shows that in 2016, there were increases in container port throughput (TEUs) from 2017 to 2019 for the total summation of Treatment Ports (DTrp), while for the Control Ports (CONTp) constant trend was seen during those periods. Therefore, the parallel trend assumption holds for the Treated Ports (DTrp) and Control Ports (CONTp) because the Container throughput moves in tandem with each other until 2016, rapid growth container throughput (TEUs) was observed from that period to 2019 for the treated ports (DTrp).

CHAPTER 5

# Conclusion

This study examined the impact of PCE on 100 ports within the LAC region from 2010 to 2019. The DID model was used to assess the causal effect of the PCE on container throughput (TEUs) among ports within the LAC region which includes the three (3) subregions and major transshipment ports. This method was significant for analyzing the Pre and Post PCE era's impact on regional ports since the advent of Neo-Panamax and Post-Panamax vessels (Mega-ships) transiting the PCE in 2016. The DID model's finding revealed that PCE has positively impacted container throughput volumes among LAC regional ports except for the Caribbean regional transshipment ports (DTrp) that experienced TEUs' losses since the PCE (Intervention). The findings were important in evaluating the PCE's causal effect on container throughput volume among LAC ports and determining endogenous factors that may affect regional port competitiveness.

Despite its limitations, the DID model is an alternative approach in impact evaluation that can be used to assess the effectiveness of governmental policies, environmental policies, and socio-economic programs [8](Hawkins et al. 2015). The DID model can also be used as a guide for policymakers to improve or adjust an intervention's outcome for regional ports. Limited studies were conducted on the DID approach in the maritime sector; therefore, it is recommended that future studies use the DID approach with other variables such as GDP, DFI, and environmental policies (MARPOL Annex VI), to determine the holistic impact of the PCE on the ports within the LAC region.

In general, the maritime sector is volatile and sensitive to the dynamic changes within global trade. Therefore ports that are proactive in assessing the effectiveness of a policy or intervention will have a competitive edge in adjusting or improving endogenous factors (e.g., policies, infrastructure, and trade) to remain sustainable in the maritime industry.

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