Estimating Key Statistics for Port Development for Ports with Limited Statistical Data Using AIS Data

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Contents

1. Introduction

- Port statistics are critical for decision-making across all stages of port development.

Phase	Key Statistics	Purpose
Development Phase	– Port capacity data – Cargo throughput forecast data	Feasibility and benefit analysis
Operational Phase	– Cargo volume – Number of ship arrivals – Berthing time statistics	Improving efficiency and productivity
Policy-Making (KMI, 2021)	– Cargo volume – Handling capacity – Productivity – Service levels – Emissions of air pollutants	Key indicators for policy decisions
Performance Assessment (World Bank's Container Port Performance Index)	– Ship sizes – Berthing times – Number of ship arrivals – Berth productivity – Cargo volumes	Assessing port performance

1. Introduction

▶ Port statistics are hardly obtainable for highly secretive countries such as North Korea.

- No official statistics on North Korean port trade volumes since 1984. (Korean Ministry of Oceans and Fisheries, 2018)
- Previous studies depend on the indirect information gathered from North Korean publications like “Joseon Geography” (1980s) and statistics from the North Korean Academy of Social Sciences (2010s).
- Global portals like IHS Global Insight are used to estimate port cargo volumes by utilizing National-scope trade data.

▶ The lack of fully systematized port infrastructure results in insufficient data on port activities.

- Port statistics for Pacific Island Countries are provided by organizations like UNCTAD and IHS Markit, but they offer them by country, and some countries and years are missing.
- The World Bank provides database statistics on social and economic factors by country but does not offer specialized data for shipping and ports.
- The Asian Development Bank (ADB) conducts specific project analyses for feasibility studies and port development but does not provide quantitative data for each port in the Pacific Island Countries. (ADB, 2020)

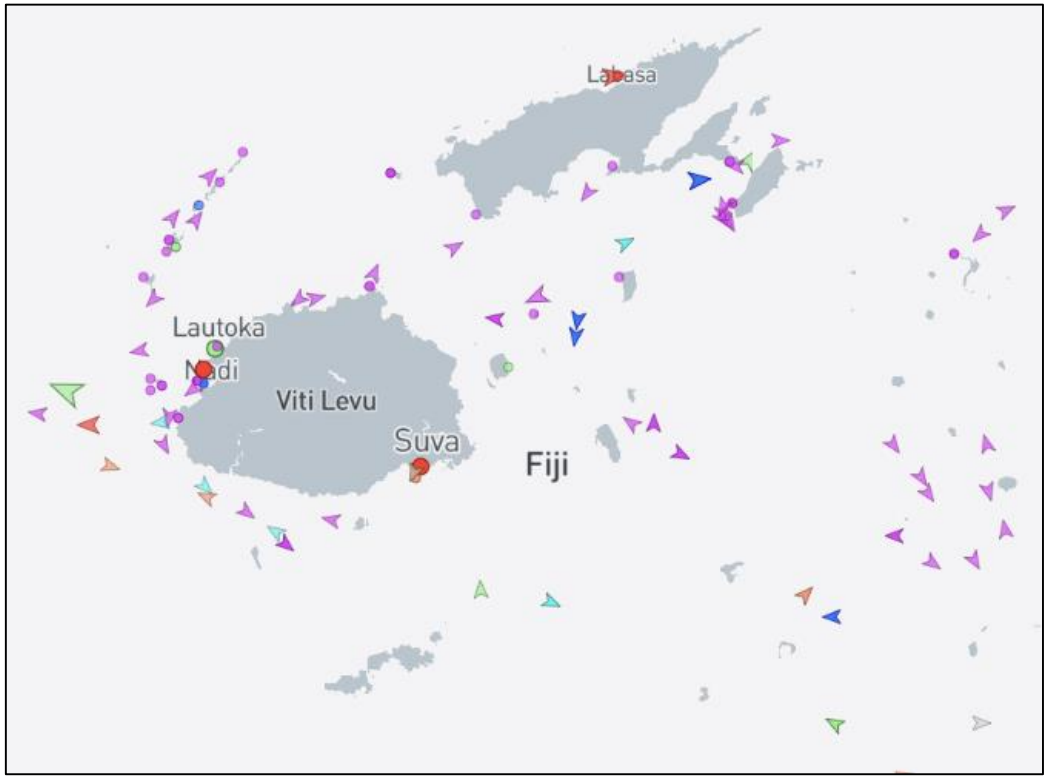
1. Introduction

▶ AIS Data Has Potential for Resolving This Issue

– The AIS (Automated Identification System) is a satellite device mandatory for international cargo ships over 300 tons and domestic cargo ships over 500 tons. AIS data record real-time information such as ship positions, speeds, and drafts every few seconds to minutes.

Static Information (ship characteristics)	Dynamic Information (ship movement)	Voyage-related Information (current voyage)
• Maritime Mobile Service Identifier (MMSI) • International Maritime Organization (IMO) Number • Call sign • Ship name • Type • Dimensions	• Ship's position (longitude, latitude) • Speed over ground (SOG) • Course over ground (COG) • Navigation status	• Destination • Estimated time of arrival (ETA) • Draught

Source: United Nations Global Platform AIS Handbook.



Source: https://www.marinetraffic.com/en/ais/home

1. Introduction

- Academic and research institutions have recently been attempting to estimate port statistics using AIS data.

Research Subject	Studies
COVID-19 Disruptions in Maritime Activities	Millefiori et al. (2021); March et al. (2020); Depellegrin et al. (2020); Verschuur, Koks, and Hall (2021); Cerdeiro and Komaromi (2020)
Trade Volume Estimation	Cerdeiro and Komaromi (2020); Arslanalp, Koepke, and Verschuur (2021); Arslanalp et al. (2019); Yan et al. (2020)
Environmental Emissions Estimation	Jalkanen et al. (2009); Shi and Weng (2021); Goldsworthy and Goldsworthy (2015); Tichavska and Tovar (2015); Winther et al. (2014); Huang et al. (2020)
Environmental Impact Assessment	Eide et al. (2007); Metcalfe et al. (2018); Vicente-Cera et al. (2020)
Port Congestion Analysis	Abualhaol et al. (2018); Peng et al. (2023)

- Our research aims to analyze and develop AIS methodologies actively studied by many researchers to apply them to ports with limited statistical data and establish statistics.

1. Introduction

- Thus, we aim to establish the following statistics for Ports with limited data using AIS data:

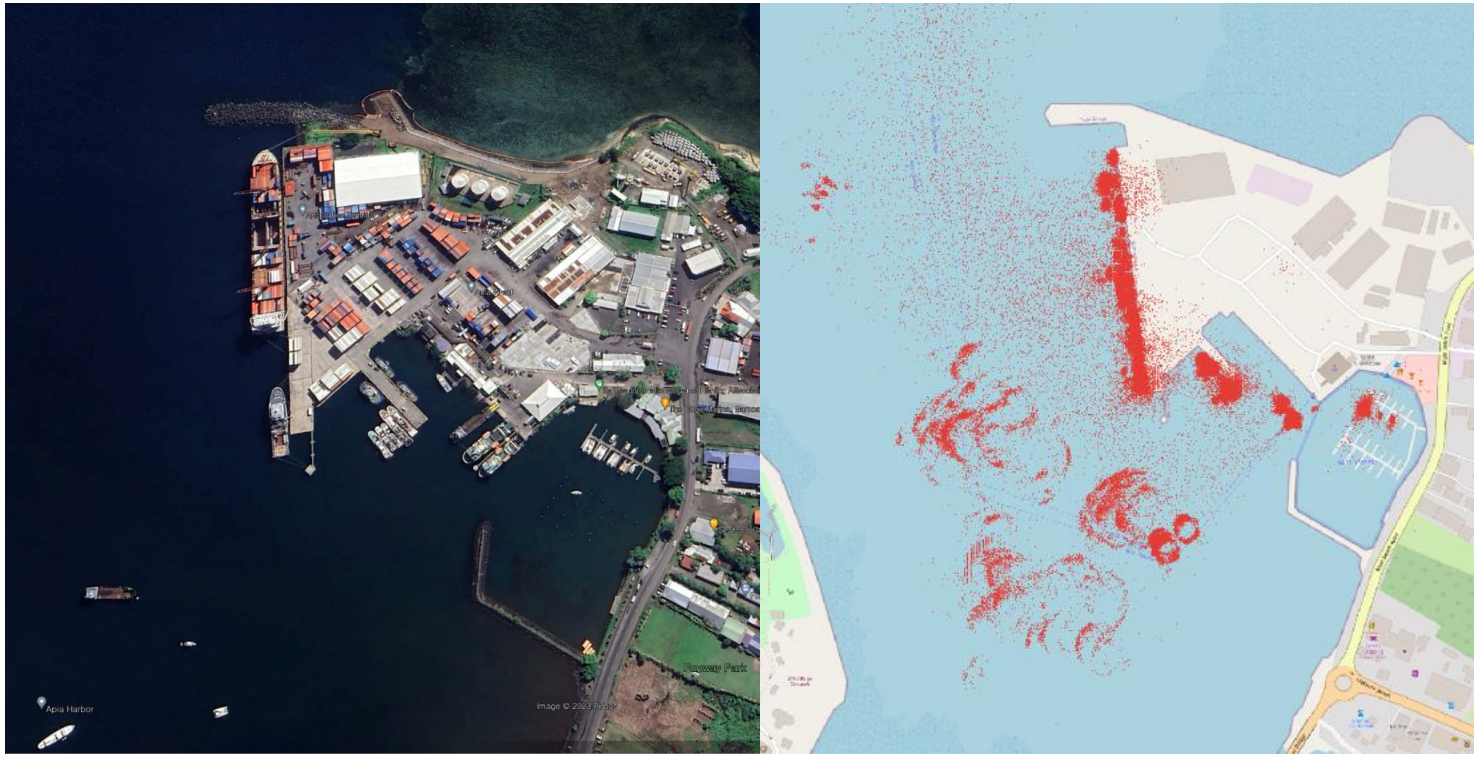
  - Establishing Statistics on Ship Specifications and Port Calls
  - Establishing Statistics on Berthing Time and Waiting Time for Ships
  - Establishing Statistics on Port Cargo Throughput

- In this presentation, we will explain each methodology for establishing these statistics and present the results of the 2022 pilot study conducted at the Port of Suva (Fiji), the Port of Apia (Samoa), and the Port of Nampo (North Korea).

2. Establishing Statistics on Ship Specifications and Port Calls

- (Defining Port Areas) Derived port areas by comparing IHS Markit ‘Ports & Terminal Guide’, Google Satellite, and AIS data.
- (Extracting Ships) Identified ships using unique identifiers such as MMSI (Maritime Mobile Service Identity).
- (Defining Voyages) Classified a new voyage if the same ship's AIS data within the port area had a recording gap of more than 24 hours.

▶ Comparison between Satellite image and AIS data(Apia Port)



2. Establishing Statistics on Ship Specifications and Port Calls

▶ Cargo Ships Calling at Apia Port in 2022

Ship Type	Average Gross Ton	Average TEU
Container Ship (14)	16,167	1,446
General Cargo Ship (4)	7,260	687
General Cargo Ship with Ro-Ro facility (4)	17,644	942
Etc. (5)	3,817	-

▶ Example of Ships Calling at Apia Port

(Left: Coral Islander II, General Cargo Ship; Right: Samoa Express II, Landing Craft)

Source: Marine Traffic

▶ Number of Ship Calls by Type at Apia Port in 2022

No.	Ship Type	Detailed Ship Type	Total Calls	Average Calls per ship
1	Cargo	Landing Craft	80	26.7
2	Cargo	Container Ship (Fully Cellular)	64	4.6
3	Cargo	General Cargo Ship	36	9.0
4	Passenger	Passenger/Ro-Ro Ship (Vehicles)	28	14.0
5	Cargo	General Cargo Ship (with Ro-Ro facility)	23	5.8
6	Passenger	General Cargo/Passenger Ship	15	15.0
7	Tanker	Chemical/Products Tanker	8	1.0
8	Passenger	Passenger/Cruise	6	1.0
9	Pleasure Craft	Yacht	4	2.0
10	Cargo	Cable Layer	3	1.5
11	Etc.	Etc.	11	1.4
Total	-	-	275	-

2. Establishing Statistics on Ship Specifications and Port Calls

▶ Ships at Nampo Port in 2022

Ship Type	Number
Cargo	120
Tanker	12
Fishing	29
Etc.	23
Total	184

▶ Cargo Ships Calling at Nampo Port in 2022

Ship Type		Number	Average Gross Ton	Average TEU
Cargo (Identifiable by IMO number)	Bulk Carrier	6	13,640	–
	Container Ship (Fully Cellular)	3	3,076	224
	General Cargo Ship	80	3,377	–
	Grab Dredger	1	1,894	–

▶ Number of Ship Calls at Nampo Port in 2022

No.	IMO Number	Detailed Ship Type	Gross Ton	Total Calls
1	A	General Cargo Ship	2,997	24
2	B	General Cargo Ship	2,998	18
3	C	General Cargo Ship	4,405	12
4	D	General Cargo Ship	2,612	9
5	E	General Cargo Ship	3,548	4
6	F	General Cargo Ship	1,923	2
7	G	General Cargo Ship	5,552	2
8	H	General Cargo Ship	1,438	2
9	I	General Cargo Ship	1,258	1
10	J	General Cargo Ship	2,980	1
11	K	Container Ship (Fully Cellular)	3,968	1
12	L	General Cargo Ship	3,623	1
Total	–	–	–	77

3. Establishing Statistics on Berthing Time and Waiting Time for Ships

Measuring Berthing Time

- **(Setting Berth Area)** Derived berth areas by comparing IHS Markit 'Ports & Terminal Guide', Google Satellite, and AIS data.
- **(Calculating Berthing Time)** Calculated the berthing time for each ship by subtracting the departure time from the arrival time at the berth from the departure time.

Measuring Waiting Time

- **(Extracting Ships for Loading/Unloading)** Extracted data for ships that berthed and performed loading/unloading operations (to exclude ships merely passing nearby).
- **(Setting Anchorage Area)** Identified the anchorage area where ships wait for loading/unloading operations.
- **(Calculating Waiting Time)** Calculated the waiting time for each ship by subtracting the arrival time at the anchorage from the departure time.

Movement Route of Ships at Apia Port (IMO 8907412, Full Container Ship)

Average Berthing Time and Waiting Time by Ship Type, Port of Suva, 2022

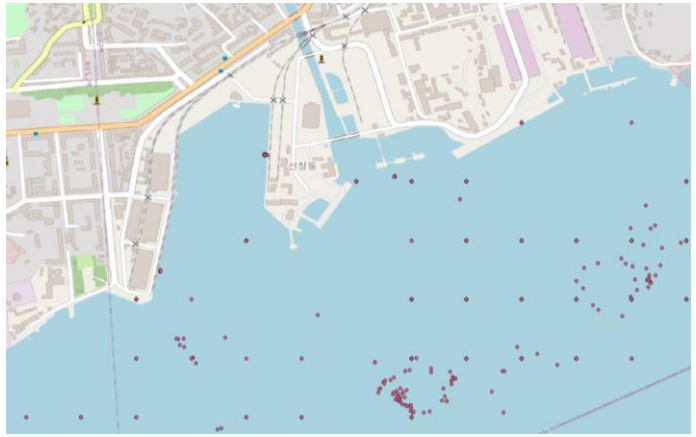
No.	Ship Type	Detailed Ship Type	Average Berthing Time(hr)				Waiting Time(hr)
			Kings Wharf	Princess Wharf	Walu Bay	Muaiwalu	
1	Cargo	Bulk Carrier	141.0	–	179.7	–	32.8
2	Cargo	Cable Layer	15.7	–	49.1	–	3.0
3	Cargo	Container Ship (Fully Cellular)	44.6	–	2.7	–	12.7
4	Cargo	Fish Carrier	7.4	–	–	–	40.4
5	Cargo	General Cargo Ship	22.6	–	5.7	–	15.5
6	Cargo	General Cargo Ship (with Ro-Ro facility)	36.0	–	–	–	12.8
7	Cargo	Landing Craft	–	–	–	73.0	11.0
8	Cargo	Offshore Support Vessel	–	–	36.4	–	–
9	Cargo	Refrigerated Cargo Ship	62.6	16.7	6.7	–	398.7
10	Cargo	Vehicles Carrier	10.7	–	–	–	3.5
11	Tanker	Asphalt/Bitumen Tanker	8.3	–	–	–	–
12	Tanker	Chemical/Products Tanker	43.1	–	–	–	6.6
13	Tanker	LPG Tanker	13.2	–	8.0	–	15.0
14	Tanker	Products Tanker	32.0	–	–	–	3.5
15	Fishing	Fishery Research Vessel	–	69.9	–	–	16.9
16	Fishing	Fishing Vessel	6.4	37.5	4.1	76.5	57.4
17	Passenger	Passenger Ship	–	–	–	174.7	0.9
18	Passenger	Passenger/Cruise	9.6	–	–	–	9.2
19	Passenger	Passenger/Ro-Ro Ship (Vehicles)	–	–	–	128.9	2.6

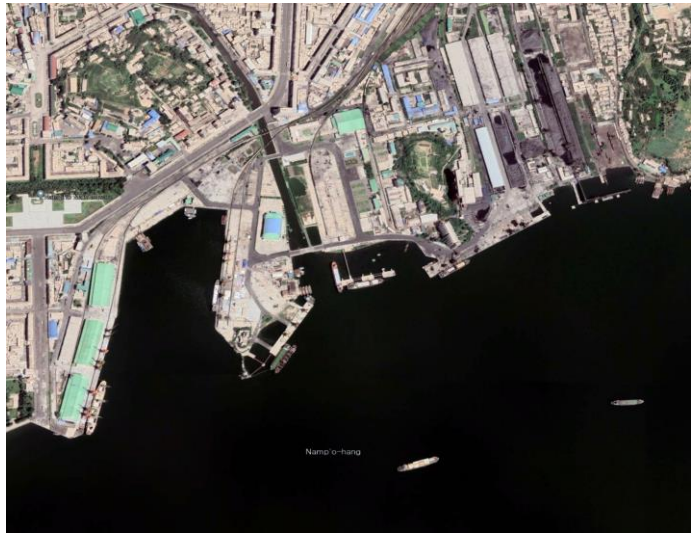
Berthing Time by Berth Type, Port of Nampo, 2022

No.	Detailed Ship Type	Liquid	Bulk	Container
1	General Cargo Ship	1.3	136.2	20.5

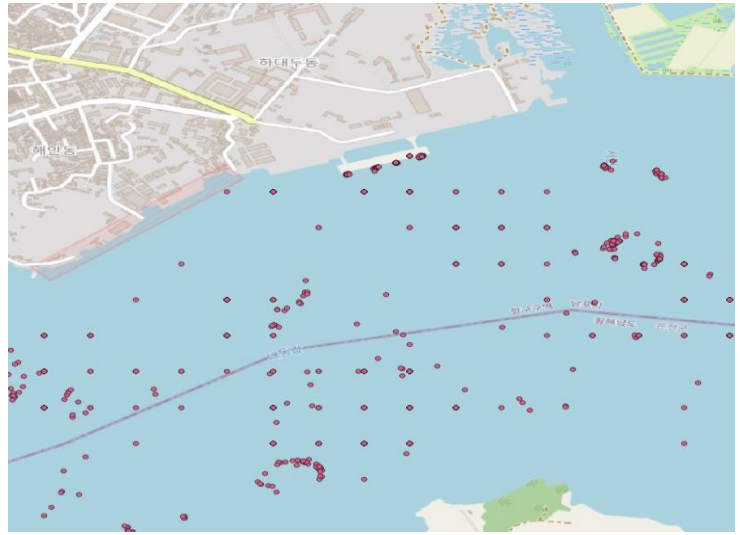
Liquid cargo berth

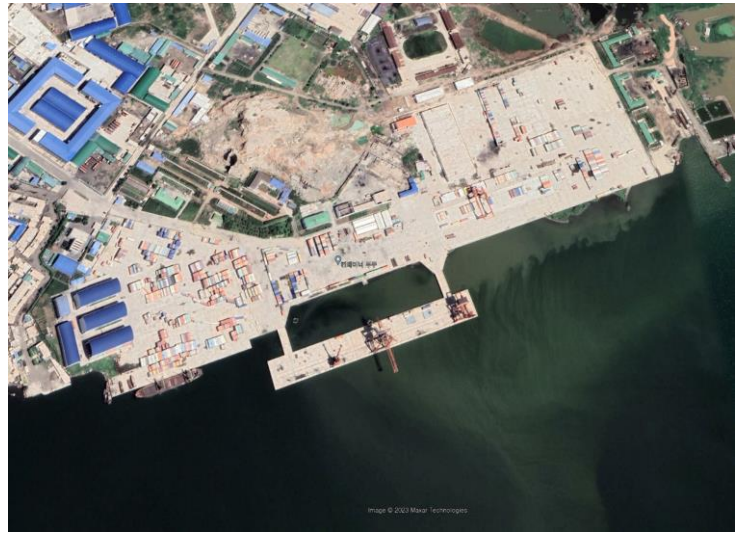
Bulk cargo berth





Container berth





4. Establishing Statistics on Port Cargo Throughput

- Cargo Throughput Estimation

Select the most appropriate AIS-based cargo throughput estimation model for Pacific Island ports, utilizing available data such as deadweight tonnage, draught, block coefficient, and crane productivity.

- Estimation Methods Considering Cargo and Vessel Characteristics

Bulk carriers typically load a single type of cargo at the point of origin and unload nearly 100% at the destination. In contrast, container ships usually operate on routes that include multiple ports, unloading only a portion of the loaded cargo and possibly loading additional cargo. Thus, analyzing handling volume based on service time may be advantageous for estimating port cargo throughput.

No.	Model		Formula	Source
1	DWT	Deadweight ton model	$TradeVolume_t = \sum_i DWT_{i,t}$	Adland, Jia, and Strandenes(2017)
2	CWI	Deadweight ton +Draught model	$CWI_t = \sum_i DWT_{i,t} \frac{\lvert d_{i,t}^D - d_{i,t}^A \rvert}{\max(d_i)}$	Arslanalp. Marini, & Tumbarello(2019)
3	AIS-SHIP1	Deadweight ton +Draught model	$AIS\_SHIP_t^{No.1} = \sum_i DWT_{i,t} \frac{\lvert d_i^{dep} - d_i^{arr} \rvert}{\lvert d_{i,deg} - d_i^{arr} \rvert}$	Hwang, S. J. et al. (2021), KMI
4	AIS-SHIP2	Block coefficient-based model	$AIS\_SHIP_t^{No.2} = \sum_i DWT_{i,t} \frac{\lvert Cb_i^{dep} - Cb_i^{arr} \rvert}{\lvert Cbd_i - Cb_i^{arr} \rvert}$	Hwang, S. J. et al. (2021), KMI
5	CP	Crane productivity-based model	$ConVolume_t = \sum_i SrvcTime_{i,t} \times CrnProd_i$	Cho, S. H. et al. (2023), KMI

4. Establishing Statistics on Port Cargo Throughput

Issue: Lack of Data for verification

- There is no data for verifying port throughput yet.
- Port of Apia explains more than 95% of Samoa's international maritime trade volume.
- We used Samoa's international maritime trade volume(IHS Markit) as proxy of Apia's port throughput.

Estimation of port throughput by ship types and cargo types

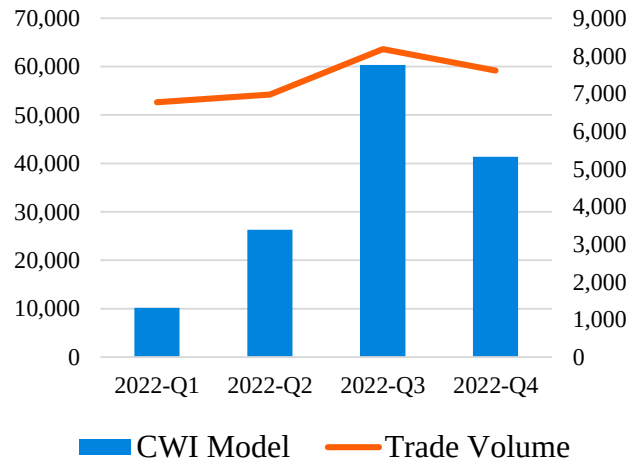
- **(Container ship)** Check correlation with container trade
- **(Tanker)** Check correlation with liquid bulk trade
- **(General Cargo ship)** Check correlation with general cargo trade volume

Samoa and Fiji's Maritime Trade Volume (IHS Markit)

Port	Cargo Type	22-Q1	22-Q2	22-Q3	22-Q4
SAMOA	Container(TEU)	6,768	6,975	8,179	7,609
	General cargo	12,354	12,064	20,901	23,062
	Liquid bulk	21,281	14,795	25,196	38,499

Estimation Result

Port	Cargo Type	Selected Model	Correlation
APIA	Container	CWI	0.98
	General	AIS-SHIP2	0.99
	Liquid bulk	Crane Prod.	0.90



5. Conclusion

Summary and contributions

- **Key Statistics Established**: We successfully established key statistics such as ship specifications, berthing times, and cargo throughput using AIS data.
- **AIS Methodology Application**: Our research applies AIS data to ports with limited data, providing a new approach to estimate vital metrics.
- **Pilot Study Validation**: The pilot study in Suva, Apia, and Nampo demonstrates the effectiveness of AIS data for building port statistics.
- **Impact**: This work lays the groundwork for improving port management in data-scarce regions using AIS data.

Next step

- Validation/verification of the model and result by obtaining data of Pacific Island Countries (On progress)
- Widen the scope of research: temporal(2019-2023), spatial(more ports)

Thank you!