SOLOMON ISLANDS

SELECTED ISSUES

May 2023

This paper on Solomon Islands was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed on April 10, 2023.

Copies of this report are available to the public from

International Monetary Fund • Publication Services
PO Box 92780 • Washington, D.C. 20090
Telephone: (202) 623-7430 • Fax: (202) 623-7201
E-mail: publications@imf.org Web: http://www.imf.org
Price: $18.00 per printed copy

International Monetary Fund
Washington, D.C.

INTERNATIONAL MONETARY FUND

SOLOMON ISLANDS

SELECTED ISSUES

April 10, 2023

Approved By	Prepared By Gabriela Cugat
Asia and Pacific Department	

CONTENTS

BIG DATA AND HIGH FREQUENCY SURVEILLANCE FOR PACIFIC ISLANDS COUNTRIES: AN APPLICATION TO SOLOMON ISLANDS[1]

Pacific Islands Countries typically have capacity constraints that prevent them from publishing timely high-frequency data, a key input for macroeconomic surveillance in general and especially during disruptive events, such as social unrest, natural disasters, or a pandemic. This project aims to fill that gap by implementing a simplified version of Arslanalp, Koepke and Verschuur (2021) using satellite-based vessel tracking data from the Automatic Identification System on ships activity to nowcast monthly trade flows. Additionally, we use port activity data to estimate economic disruptions due to social unrest in 2021.

A. Introduction

1.   **The COVID-19 pandemic has emphasized the need for timely economic activity indicators during unprecedented events; in turn, the use of unconventional data in surveillance is becoming increasingly common.** However, many of these indicators, such as Google's mobility reports, are not available for Pacific Islands countries (PICs) given their small size and remote location. Official high frequency data is scarce, and oftentimes is available with a lag of two to three months. One data source that can be used to fill in data gaps for PICs is the Automatic Identification System (AIS) data, a tracking system for ships that compiles vessel-traffic data.

2.   **AIS data can be used to estimate port activity and trade flows, allowing for almost immediately available** indicators (**with a lag of just a couple of days) and for tailored granularity, as the user decides on the level of aggregation.** Solomon Islands is a good candidate for using AIS data to estimate trade flows as about 80 percent of trade is carried by sea and shipments in each port tend to be in one direction (focusing either in exports or imports). We use AIS data to compute a set of monthly estimators of port activity (total, by port, by activity, and inter-island), and to estimate the volume of exports and imports.

3.   **The following section describes the data and methodology used, while sections C and D report results for port activity and trade flow estimates respectively.** The final section concludes.

B. Data and Methodology

4.   The Automatic Identification System (AIS) is an automated tracking system, originally developed by the International Maritime Organization (IMO). It has global coverage, made available in real time by different data providers. AIS is a collaborative, self-reporting system, which allows vessels to periodically broadcast their identity, navigation and position data and other characteristics. AIS uses Global Positioning Systems (GPS) in conjunction with shipboard sensors and digital Very High Frequency radio communication equipment to automatically exchange navigation information electronically. AIS has been made compulsory for international commercial ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size. AIS messages include both static and voyage related information, updated every 6 minutes, as well as dynamic information, updated every 2 to 10 seconds when the ship is in movement or every 6 minutes when anchored. See Table 1 for a summary of the different messages transmitted.

Table 1. Solomon Islands: Automatic Identification System Messages			
Message type	Content	Source	Frequency
Static, Identity related	Ship callsign, IMO number, mmsi number, vessel name, vessel type, size, flag.	Manual.	Every 6 minutes.
Static, Voyage-related	Destination, Estimated Time of Arrival (ETA), draught.	Manual input by crew.	Every 6 minutes.
Dynamic	Vessel speed, geospatial location (latitude and longitude), heading, time.	Automatic.	2-10 seconds when moving, every 6 minutes when anchored.

Source: UN Statistics (2020).

5.   Marine vessels use AIS in coordination with Vessel Traffic Services to monitor vessel location and movement primarily for traffic management, collision avoidance, and other safety applications. However, more and more unconventional applications of the AIS data are emerging, particularly as complements for official statistics.[2] In the present case, we use the methodology developed by Arslanalp, Marini and Tumbarello (2019) and Arslanalp, Koepke and Verschuur (2021) (AKV from now on) to estimate trade flows.

6.   We access the AIS data through the UN Global Platform (UNGP), that contains live data and global archive data since December 1, 2018. The UNGP provides the AIS data from ExactEarth, as well as the IT infrastructure to process the data. National and international agencies

---

[2] Other uses of the AIS data include Port statistics and port performance analysis, nowcast and forecast trade flows: Arslanalp and others (2019), Arslanalp and others (2021), to Monitor fisheries Estimate maritime CO2 emissions, or to complement official statistics as done by Denmark and Norway that publish the daily number of vessels that visit their ports or by the UK that publishes monthly shipping indicators based on AIS data.

that are members of the UN-CEBD can request access to the UNGP. We pull the AIS data for every available month from January 2019 to January 2023.

7.   The AIS data is stored using Uber's hexagons definition. To access the data, we use the area of the Solomon Islands ports defined by AKV (based on information from the World Port Index, Google Maps, and satellite images of vessel movements in and around the port) and we cover the area with level 8 hexagons (see Figure 1 for the Honiara port and Annex II for all ports).

Figure 1. Solomon Islands: Area of the Honiara Port

Source: IMF staff computations.

8.   A port call is defined as a vessel's visit to a port, with a clearly defined entry and exit. We pull all observations within port boundaries on a monthly basis and define a port call by the dates of the first and last time a vessel is observed within port boundaries. Our algorithm checks port calls at the beginning of the month and combines them with a port call that was finishing at the end of the month if needed, as these were port calls that start in one month and finish in the following one. We drop vessels that only appear one time within port boundaries, as these are likely to be errors due to data quality.[3] We use port calls to compile two sets of indicators: one on port activity, the other on trade flows.
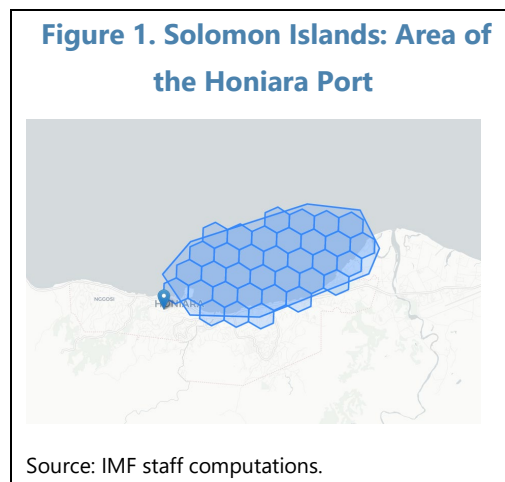
9.   For the port activity indicators, we use all types of port calls with no additional filtering and compute the count of port calls for each type of indicator. We compute an overall port activity indicator, an inter-island traffic indicator, a port activity indicator by port, and a port activity indicator by economic activity. For the indicators by economic activity, we consider the following categories: law enforcement (military and law enforcement vessels), fuel (tanker vessels), fishing, tourism (passenger, diving, pleasure craft, sailing), and trade (bulk carrier, container ships, forest-product carrier, towing, tug, and general cargo vessels). The remaining ships that cannot be identified are accounted in the residual port activity indicator. For the inter-island traffic level indicator, we count the number of vessels that are observed in more than one Solomon Islands' port within the same period.

10.   To compute our trade indicators, we consider only port calls related to trade, that is, port calls made by vessels of type Cargo (bulk carrier, container ships, forest-product carrier, and general cargo vessels), and we discard port calls shorter than 5 hours with no change in adjusted draught. We estimate trade volumes as in AKV, based on the change in utilization rate when entering and leaving the port boundary. The utilization rate is estimated using vessel characteristics (length, width, carrying capacity, and block coefficient) and draft information. One of the shortcomings of the AIS data is that ships usually update their draft information when entering a port, but not when leaving which results in some observations with no change in draft. In these

---

[3] See Arslanalp and others (2021), Arslanalp and others (2019), and United Nations (2020) for discussions on AIS data quality and potential pitfalls.

cases, we follow AKV and use local backpropagation and historical averaging to impute draft changes. Backpropagation exploits the common practice of updating the draft when entering a port and uses the incoming draft in the following port a ship enters as the outgoing draft in the port of interest. Our simplified approach uses local backpropagation, meaning we only use backpropagation when the next port visited by a ship is within Solomon Islands.[4] Historical averaging imputes draft changes with the historical average observed in the port of interest for the ship with missing data.

11.   **As in AKV, we estimate the utilization rate at the reported draft r as:**

$$\mu_r = \frac{(Cb_r d_r - Cb_d d_d)LW\rho_w + DWT}{DWT}$$

where L=length, W=width, d_d=design draft, d_r=reported draft, Cb_d=block coefficient at design draft, Cb_r=block coefficient at reported draft, ρ_w=average density of salt water (1.025 tons/m3), and DWT=dead weight tonnage. The block coefficient at the reported draft is estimated as:

$$Cb_r = 1 - \left((1 - Cb_d)\left(\frac{d_d}{d_r}\right)^{\frac{1}{3}} \right)$$

Outgoing reported draft is computed using local backpropagation as:

$$d_{r,out} = \begin{cases} d_{r,in,next} & if \ d_{r,in} = d_{r,out} \text{ and next port within SLB} \\ d_{r,out} & \text{otherwise} \end{cases}$$

12.   **Trade flows are then estimated as the difference in utilization rate when entering and leaving the port.** Import flows are given by estimates below zero while export flows are those above zero. Given the nature of imports and exports in Solomon Islands, it is unlikely that the same vessel will load exports after unloading imports. For the remaining cases with no changes in draft, trade flows are imputed using historical averaging as the historical trade observed for a given vessel in the port of interest. The estimated trade flows can be written as:

$$T = \begin{cases} (\mu_{r,our} - \mu_{r,in})DWT, & d_{r,in} \neq d_{r,out} \\ T_{average}, & d_{r,in} = d_{r,out} \end{cases}$$

13.   **The indicators we compute are likely highly correlated with economic activity, as for Solomon Islands good imports represent 30 percent of GDP** (2017-2021 average), 80 percent of merchandise imports take place by sea, and annual imports have a correlation coefficient of 0.94 with GDP (measured in US dollars, 1995 to 2021). Additionally, economic activity in PICs has been found to be highly dependent on ports, with up to 45 percent of activity dependent on ports (see Verschuur, Koks, and Hall, 2022).

---

[4] The simplified approach is easier to implement one country at a time, as it doesn't require following vessels to their next destination which might be in another country.

C. Port Activity

14.   We extract all the vessel activity in the Solomon Islands' ports and compute the various indicators of port activity to use as proxy for economic activity. The heat maps in Figure 2 show a clear decline of port activity in the Honiara port during February 2021 and 2022 compared to February 2020. The heat maps show the raw AIS location data within the Honiara port, the brighter towards red, the more activity took place in that spot. More formally, Figure 3 shows the computed total number of port calls implied by the ships' location activity from January 2019 to January 2023. Port activity decreased substantially in 2020 and 2021, by 27 percent and 42 percent when compared to the 2019 average. Port activity in 2022 remained subdued at the 2021 depressed level but displayed an increasing trend and signs of systematic recovery. Inter-island traffic broadly follows the same pattern as total port activity (Figure 4).

Figure 2. Solomon Islands: Honiara Port Activity

Panel A: February 2020   Panel B: February 2021   Panel C: February 2022

Source: AIS data.
Note: The heat maps use all the AIS location data within the Honiara port, the brighter towards red, the more activity took place in that spot.
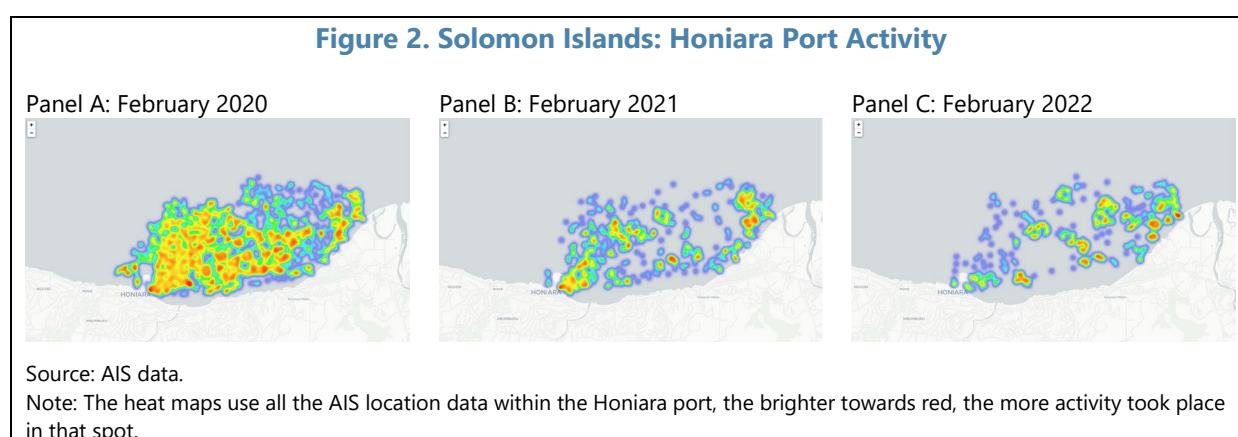
15.   An advantage of AIS-based indicators is the possibility of computing tailored indicators. Appendix II shows our port activity indicators by port and by economic activity. These breakdowns can provide additional information on the impact of the pandemic and how the recovery is unfolding. Port activity in Solomon Islands is heavily concentrated in two ports, the Honiara port (main imports port) and Port Noro (main exports port), both managed by the Solomon Islands Port Authority. The remaining ports display considerably less activity on average. Port activity declined across all ports with the onset of the pandemic, bottoming out in early 2022 with the domestic outbreak of COVID-19. A recovery trend is observed for the main ports, Honiara and Port Noro, as well as for Seghe port and Gizo Harbor.[5] The remaining ports continue displaying depressed port activity, pointing at a geographically unequal recovery.

16.   In terms of economic activity indicators, port calls related to fishing, tourism and trade plummeted with the pandemic, while fuel-related port calls fell, but remained relatively stable. The incipient recovery in 2022 seems to be broad-based across fishing, tourism, and trade. The recovery in fishing activity can be used as proxy for the recovery of fishing rents in the Balance of Payments account, while the recovery on tourism activities clearly follows the reopening of the border in mid-2022.

---

[5] Appendix III presents heat maps of port activity for Honiara and Port Noro, for the months of December 2019-2022.
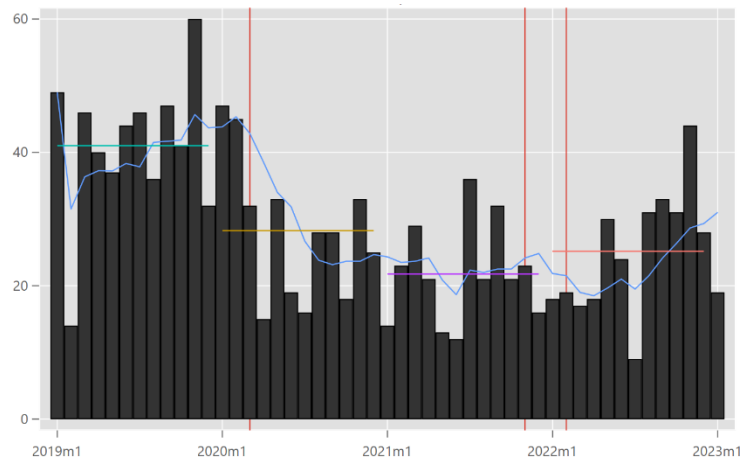
Figure 3. Solomon Islands: Total Port Activity
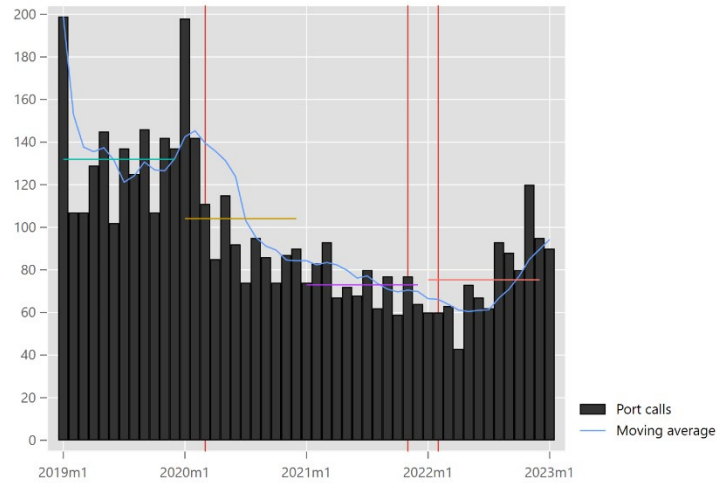
Source: IMF staff estimates based on AIS data.

Note: black bars represent monthly port calls of all types (commercial, tourism, oil tankers, law enforcement, etc), the blue line represents the six-month moving average, and horizontal lines are the yearly averages. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

Figure 4. Solomon Islands: Inter-Islands Port Activity

Source: IMF staff estimates based on AIS data.

Note: black bars represent monthly inter-island port calls of all types (commercial, tourism, oil tankers, law enforcement, etc), the blue line represents the six-month moving average, and horizontal lines are the yearly averages. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

17.   In addition to monthly port activity, the data allows for zooming in at the daily and weekly levels. Figure 5 shows the heat maps for port activity in Honiara during the November 2021 riots. The heat maps point to increased activity in the water in the week of the riots and the week after, which could be taken as a sign of the ships' inability to unload at the port as well as increased law enforcement presence. Figure 6 summarizes the number of port calls each week and the average time spent in port. Port calls fell by 30 percent in the week of the riots, while trade-related port calls fell after the riots, and law enforcement port calls increased. Ships that arrived the week before the riots spent on average a longer amount of time in the port than those that arrived in the week of the riots and the week after, which supports the claim of ships facing difficulty completing their required tasks on land. For this reason, while port calls declined, the heat maps in Figure 5 show increased activity during the week of the riots.

Figure 5. Solomon Islands: Honiara Port Activity During the 2021 Riots

Panel A: Week before the riots,
November 14 to 20
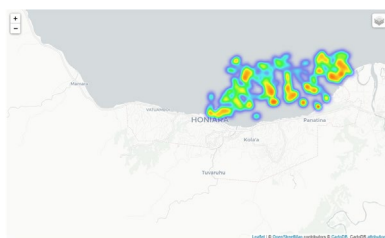
Panel B: Week of the riots,
November 21 to 27
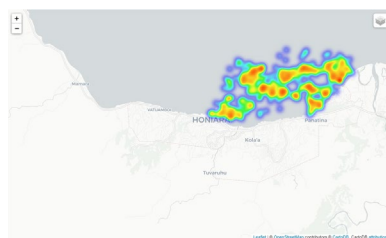
Panel C: Week after the riots,
November 28 to December 4
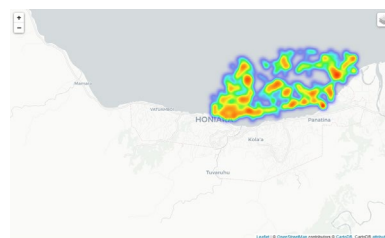
Source: AIS data.
Note: The heat maps use all the AIS location data within the Honiara port, the brighter towards red, the more activity took place in that spot.

Figure 6. Solomon Islands: Honiara Port Calls During the 2021 Riots

Panel A: Port calls, total
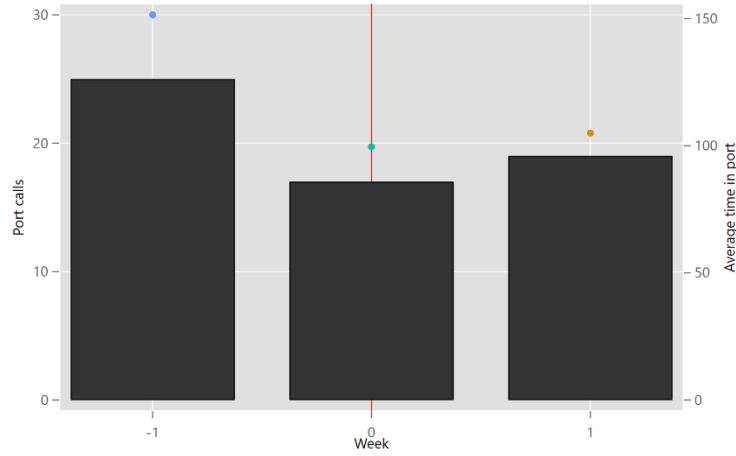
Panel B: Port calls by vessel type
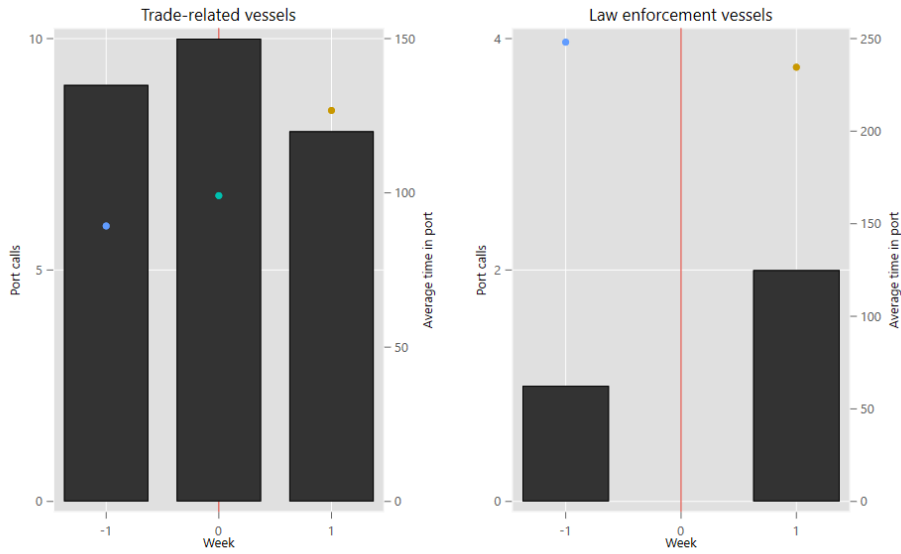
Source: AIS data and IMF staff calculations.
Note: Port calls in the Honiara port. Black bars represent the number of port calls, while color dots represent the average time in port (RHS). Week -1 refers to the week before the riots, November 14 to 20, 2021; week 0 refers to the week of the riots, November 21 to 27, 2021; and week 1 refers to the week after the riots, November 28 to December 4, 2021.

D. Trade Flow Estimates

18.   We estimate imports and exports using information from all ports and using only information from the Honiara port. For exports, we can validate our estimates comparing with the monthly volume of logs production (which is mostly for exporting) and with the Monthly Production index (covers primary production) both provided by the Central Bank of Solomon Islands (CBSI) in their monthly bulletin. We can also compare with the estimates by AKV. For imports, there is no high frequency volume estimate that can be used for validation, we only compare with the volume estimates from AKV.[6] Table 2 summarizes the correlation coefficients found, based on this, our preferred estimate for exports is the one computed using information from all ports, while for imports our preferred estimate is the one computed with information from the Honiara port.

19.   Our trade flows estimates show a lot of dynamism on the import front, with import volumes responding quickly to external and internal conditions, while on the export front the decrease due to the pandemic has shown little to no recovery since 2021. Figure 7 shows our volume estimates for exports and Figure 8 for imports, together with the monthly merchandise exports and imports value in domestic currency provided by CBSI (usually with a lag of two to three months). Differences between the import volume estimate and the value indicator point to increases in shipping costs and global supply chain disruptions (second half of 2021) and increases in shipping costs and global commodity prices in 2022 due to the war in Ukraine. For exports, we estimate a fall of 64 percent in 2021 and 2022 with respect to 2019. Our export volume estimate features a large boom at the end of 2019 and beginning of 2020 that we need to validate with other data sources and the authorities.

### Table 2. Solomon Islands: Correlation with Other High Frequency Indicators

	Logs (Volume)	Monthly Production Index	Exports AKV	Imports AKV
Exports all Ports	0.44	0.36	0.87	
Exports Honiara	-0.49	-0.52	0.12	
Imports all Ports				-0.03
Imports Honiara				0.44
Exports AKV	0.56	0.46		

Source: IMF staff estimates, CBSI, and AKV.
Note: Coefficients show the pairwise correlation of the row variable with the column variable, for the sample period January 2019 to January 2023. For the AKV variables the sample is January 2019 to February 2021.

---

[6] The methodology from AKV has been cross-checked for other PICs that do have high frequency data available.
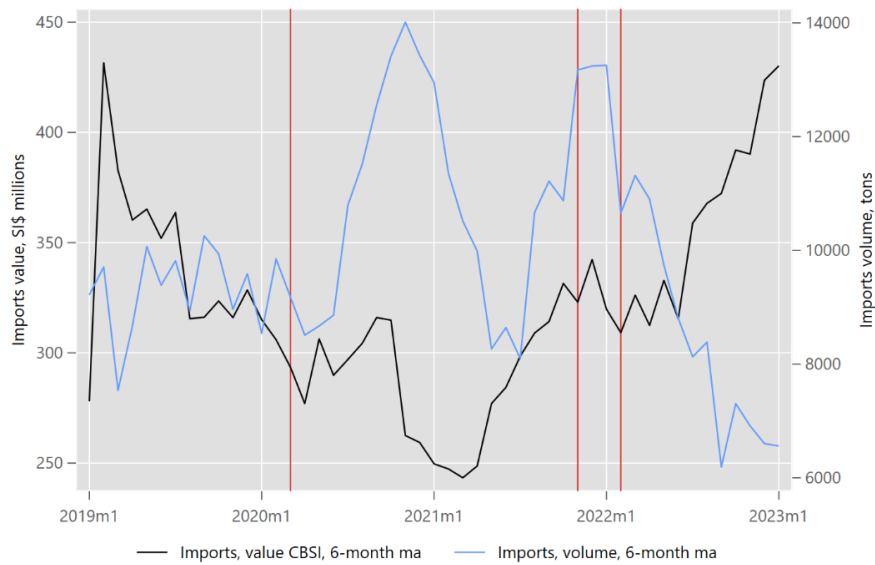
Figure 7. Solomon Islands: Export Volume Estimates
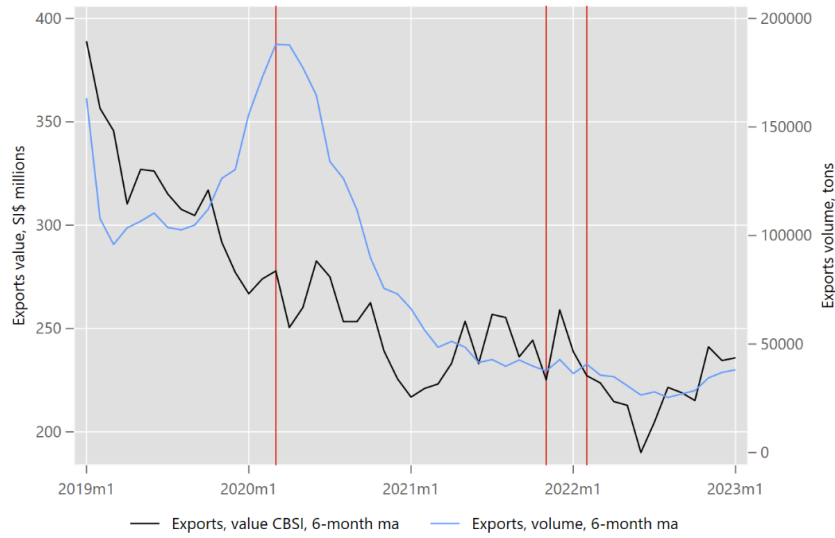
Source: IMF staff estimates based and CBSI.

Note: the blue line represents the 6-month moving average of the estimated volume of exports, while the black line is the 6-month moving average of the value of exports as provided by the CBSI. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

Figure 8. Solomon Islands: Import Volume Estimates

Source: IMF staff estimates based and CBSI.

Note: the blue line represents the 6-month moving average of the estimated volume of imports, while the black line is the 6-month moving average of the value of imports as provided by the CBSI. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

E. Conclusions

20.   Big data can be used to fill data gaps for PICs and the IMF can serve as a capacity-building and innovation hub. The estimators computed based on AIS data have been used as part of the surveillance dashboard by the Solomon Islands team and have been discussed with the authorities. The CBSI staff is exploring the use of these indicators in the context of a broader nowcasting effort under IMF technical assistance (TA). The current exercise showcases the potential for surveillance and TA integration in building capacity and filling data gaps. Initiatives like the AKV estimation exploit cross-country synergies and technical expertise available at the IMF to provide valuable inputs for both internal and external use.

21.   Other potential applications of the AIS can expand on this effort, for example some single-country applications are monitoring of fishing vessels to estimate fishing rents from daily vessel schemes, monitoring export-related ships to monitor for piracy/exports misreporting, track tourism in real time, etc. Given the global nature of the AIS data, it can also be used to analyze global supply chains, trade disruptions from natural disasters, the effect of trade policies, etc.

References

Arslanalp, S., R. Koepke and J. Verschuur, 2021, "Tracking Trade from Space", IMF Working Paper 21/225.

Arslanalp, S., M. Marini and P. Tumbarello, 2019, "Big Data on Vessel Traffic: Nowcasting Trade Flows in Real Time", IMF Working Paper 19/275.

Central Bank of Solomon Islands, Monthly Bulletin, various issues. Accessed online: https://www.cbsi.com.sb/publications/monthly-economic-bulletin/

Verschuur J., E. E. Koks, J. W. Hall, 2022, "Ports' Criticality in International Trade and Global Supply-Chains" *Nat Commun* 13, 4351 (2022). https://doi.org/10.1038/s41467-022-32070-0.

UN Statistics (2020), Overview of the AIS dataset. Accessed online at: https://unstats.un.org/wiki/display/AIS/Overview+of+AIS+dataset

UN Committee of Experts on Big Data and Data Science for Official Statistics - The AIS Task Team, United Nations Global Data Platform. https://unstats.un.org/bigdata/task-teams/ais/index.cshtml

Appendix I. Area of Solomon Islands Ports

Figure 1. Solomon Islands: Area of Ports

Honiara Port
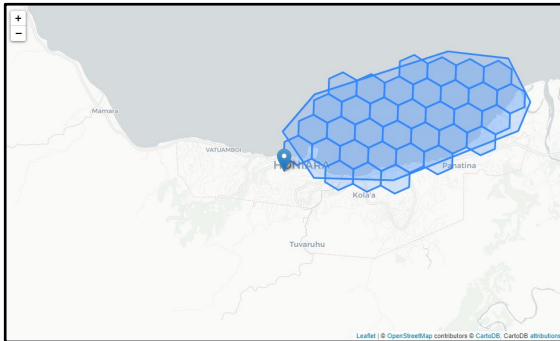
Noro Port
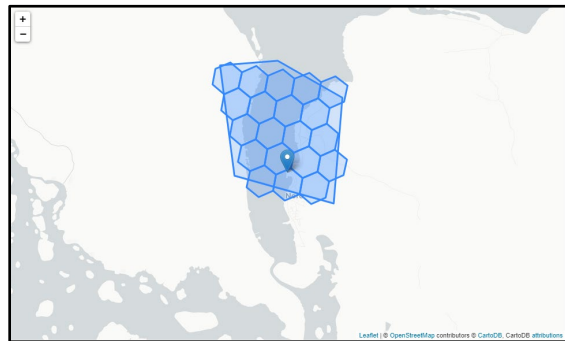
Gizo Harbor
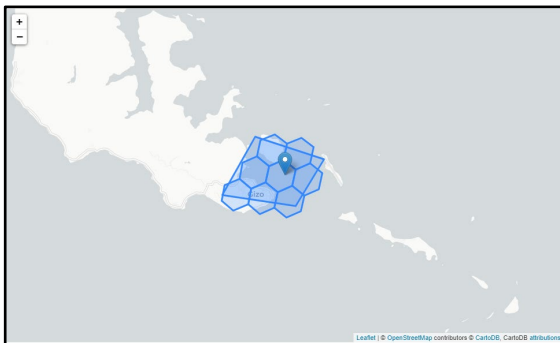
Seghe Port
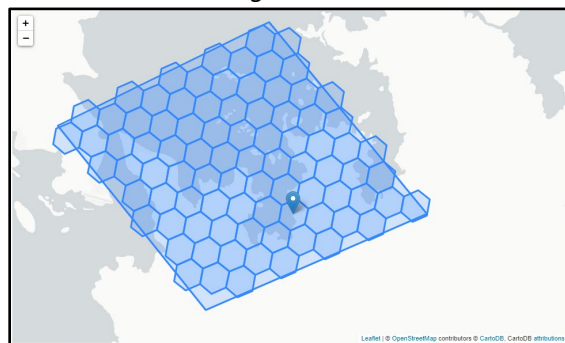
Ndora Port
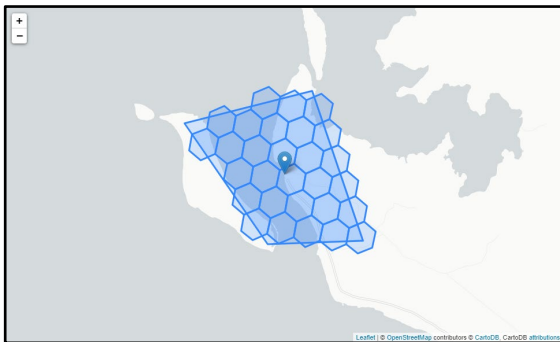
Mbulo Port
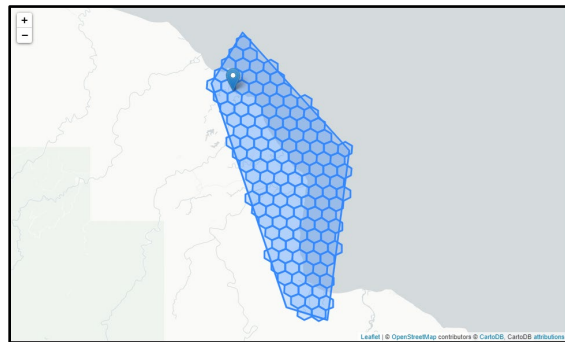
Figure 1. Solomon Islands: Area of Ports (Concluded)
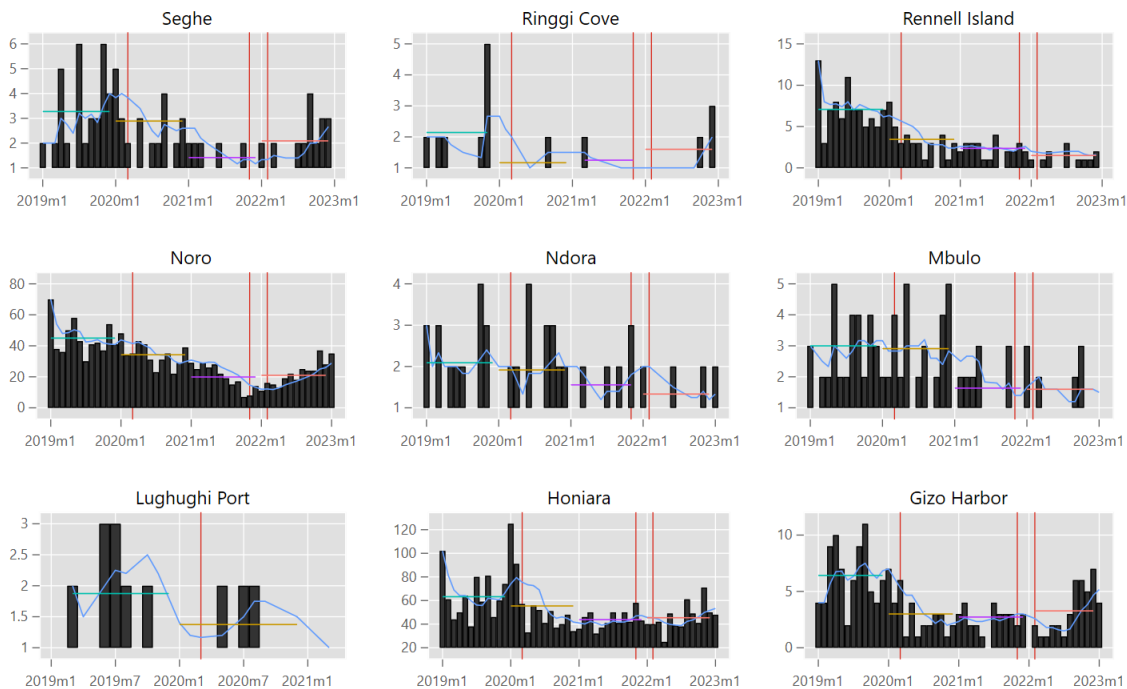
Ringgi Cove
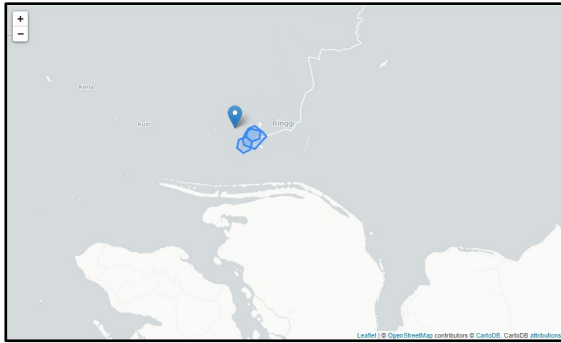
Lughugi Port
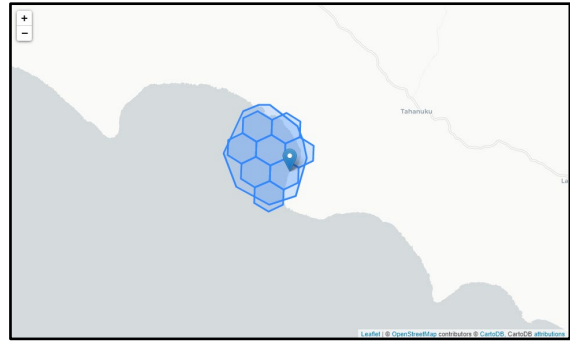
Rennell Island
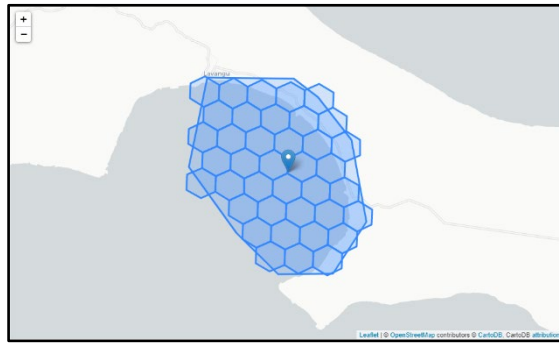
Appendix II. Granular Indicators of Port Activity

Figure 1. Solomon Islands: Total Port Activity (By Port)

Source: IMF staff estimates based on AIS data.

Note: black bars represent monthly port calls of all types (commercial, tourism, oil tankers, law enforcement, etc), the blue line represents the six-month moving average, and horizontal lines are the yearly averages. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

Figure 2. Solomon Islands: Port Activity by Economic Activity (All Ports)
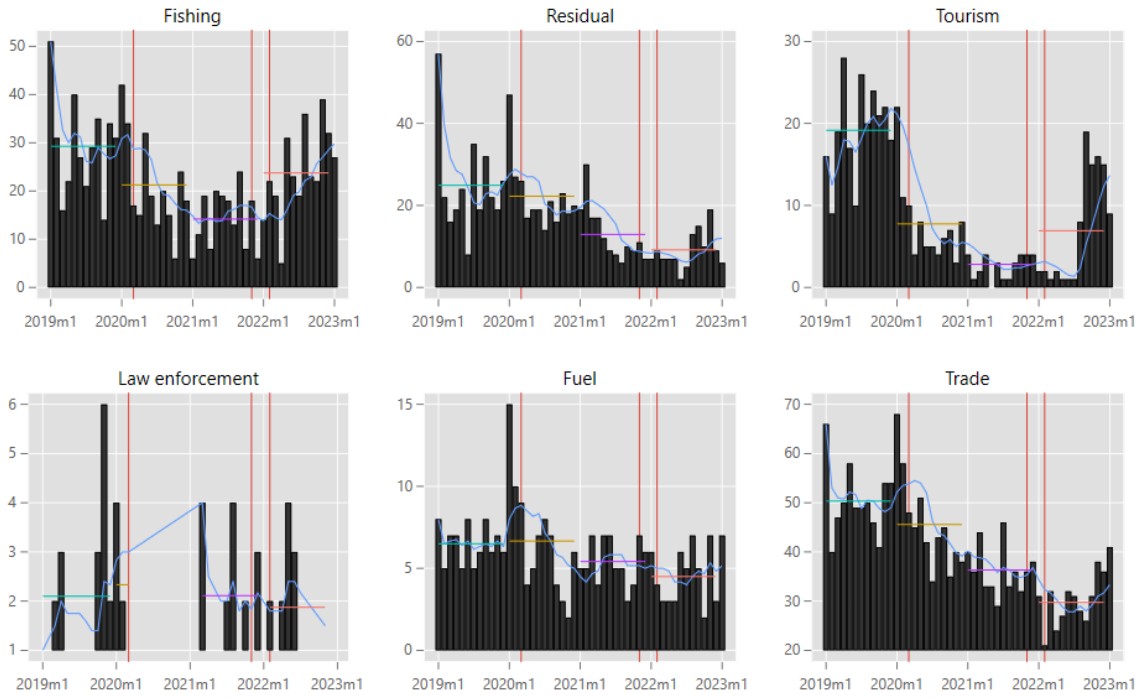
Source: IMF staff estimates based on AIS data.
Note: black bars represent monthly port calls from all ports by economic activity, the blue line represents the six-month moving average, and horizontal lines are the yearly averages. Vertical red lines represent: the start of the COVID-19 pandemic (March 2020), the November 2021 Honiara riots, and the domestic outbreak of COVID-19 (February 2022).

Appendix III. Heat Maps for Main Trade Ports

*We present heatmaps for the main imports port (Honiara) and the main exports port (Port Noro),
during the month of December, for 2019 to 2022. A point in the map is a vessel location, from
blue (fewer observations) to red (many observations). The higher the intensity of activity in the
port, the more the red areas there will be.*

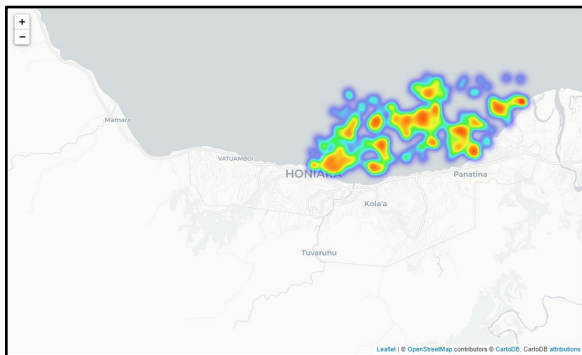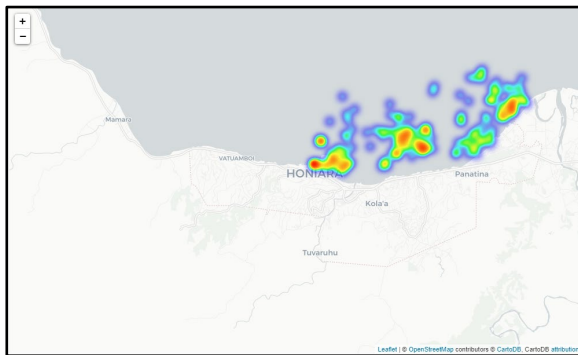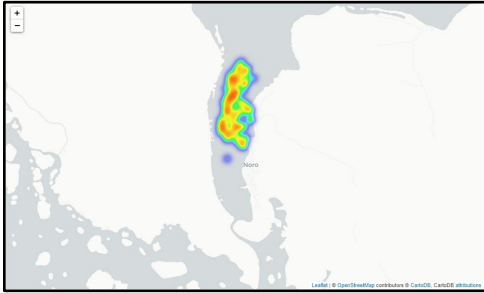### Figure 1. Solomon Islands: Honiara Port Activity (Main Imports Port)

December 2019
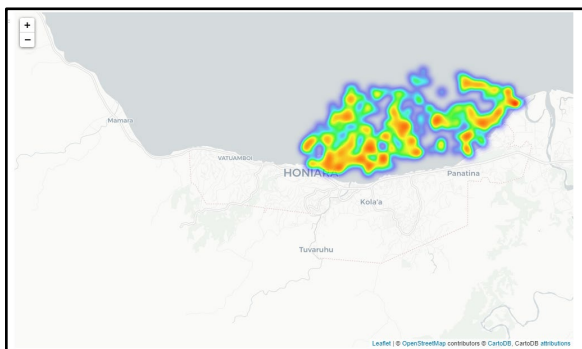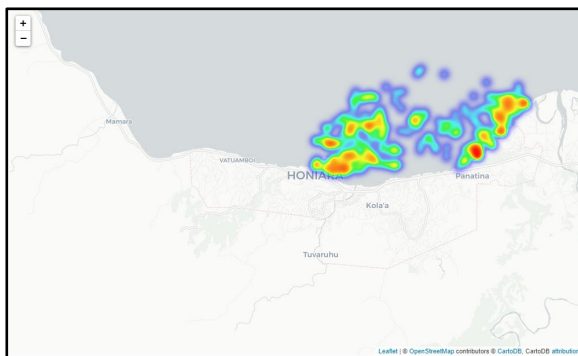
December 2020

December 2021
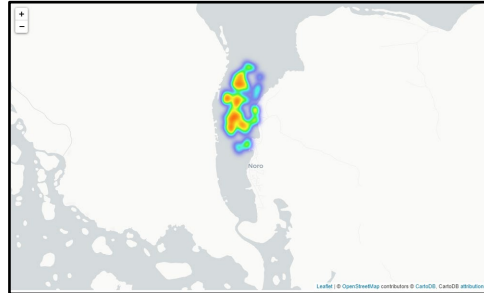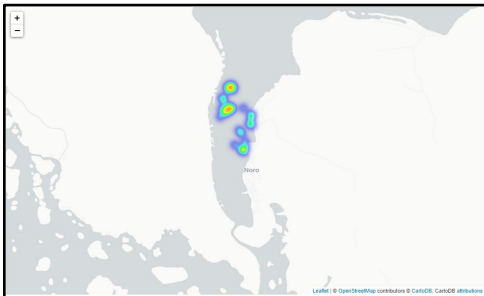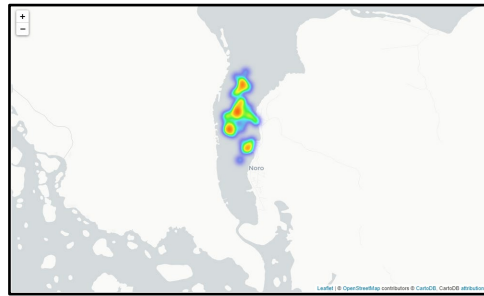
December 2022

Source: AIS data.

Figure 2. Solomon Islands: Port Noro Port Activity (Main Exports Port)

December 2019

December 2020

December 2021

December 2022

Source: AIS data.