J.P.Morgan

Economic Research
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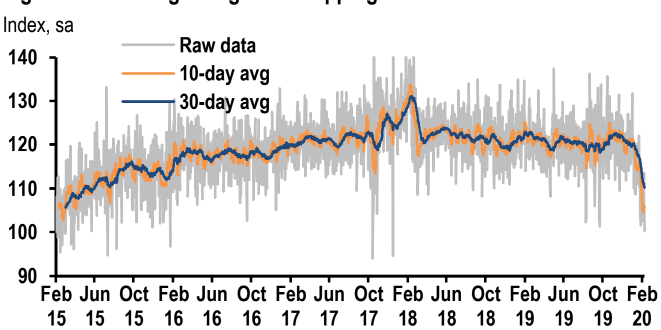
Special Report

Rocking the boat with alternative data: Introducing the JPM BIDSI trade tracker

- **We transform billions of daily marine vessel tracking points and ports data into a daily global shipping volume index—processing raw daily data of over 4 terabytes (1 TB = 1 million MB)**
- **Shipping trade gives a good indication of global trade as shipping represents over 80% of world trade by volume, with EM accounting for nearly two-thirds**
- **The daily JPM Big Data Shipping Index (BIDSI) comprehensively tracks global shipping activity; using the BIDSI, we highlight the slowdown in global trade since the start of the US-China trade war and the recent COVID-19-related impact**
- **The 10- and 30-day trailing BIDSI provides an early read on global trade activity with near-real-time data**
- **The monthly BIDSI captures trends and many turning points in EM industrial production; it also allows us to track trade activity in countries with limited data**
- **The latest data show a sharp slowdown in global shipping volumes in February 2020 in the midst of the COVID-19 outbreak; latest China volumes are around 30% lower than historical average**

Figure 1: J.P. Morgan Big Data Shipping Index - Global



Source: J.P. Morgan, MariTrace

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Executive summary

With the downturn in global trade flows amid a rise in trade protectionism and the COVID-19 outbreak, the tracking of global trade activity has become even more critical. In this note, we use alternative data as an innovative way to capture shipping trade—by far the most-used form of transport in global trade and EM in particular—to produce highly accurate daily series of trade flows. This is the first time we have compiled trade data at this frequency and scale.

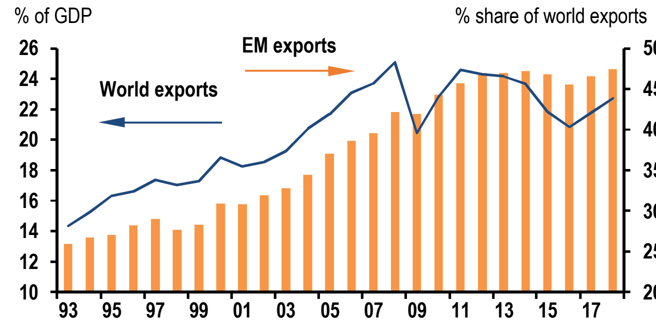
Nowadays, vessels worldwide can be tracked in almost real time. Commercial ships are equipped with a device that periodically sends a radio signal (an Automatic Identification System message, or AIS[1]) that contains information on the vessel's location, speed, destination, draught, etc. However, the challenge of using raw AIS data is the sheer volume. AIS records around 165,000 unique ships, and in total, these ships generate an estimated 19,000 AIS messages per second with a data generation rate of 48MB a second. This results in approximately 1.6 billion AIS messages, or over 4 terabytes of data a day (4.1 million MB). We use this in combination with an estimate of the weight of the cargo to build a database of daily shipping flows—the J.P. Morgan Big Data Shipping Index (BIDSI).

In this note, we first present the daily and monthly BIDSI. We then discuss how the BIDSI differs from other widely used high-frequency indicators of global trade activity as well as its advantages over official trade statistics with respect to timeliness, accuracy, and reliability. We show how the BIDSI gives us an early signal of real activity such as industrial production and near-real-time insight into international trade flows. The analytical section ends with using the BIDSI to track Chinese trade activity during the COVID-19 outbreak. A section on methodology and detailed explanation of AIS data follows the analytical section. Finally, we present ideas for future projects using the BIDSI data in our conclusion. The appendix section includes some case studies (e.g.: Boeing 737 MAX shutdown and Cyclone Veronica) to show potential use cases for the BIDSI at a more granular and specific purpose.

The importance of capturing global trade

In the 1960s, the sum of worldwide exports accounted for less than 10% of global output. Today, the value of exported goods around the world is around 23% of GDP. EM's share in world trade has increased dramatically to about 45% in 2018 from less than 25% in 1999 (Figure 2).

Figure 2: World exports and EM share of world exports



Source: J.P. Morgan

Trade growth is also a strong indicator of global GDP growth (Figure 3). Developments in the global supply chain have meant that materials and manufactured goods are no longer sourced from neighboring countries, but rather from the cheapest source, often on the other side of the world. Trends in air and sea traffic, relative to land-based transport, have reflected these shifts.

Figure 3: Global growth and global trade

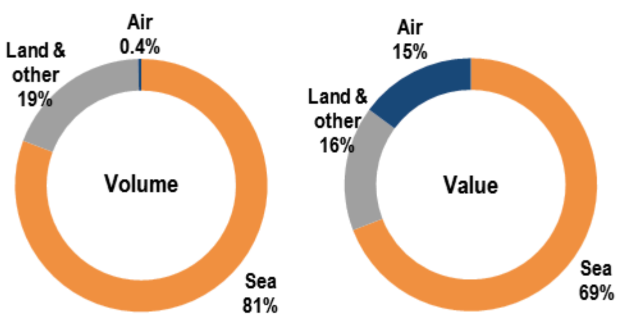
Source: J.P. Morgan, CPB

Over 80% of global merchandise trade by volume and around 70% by value is carried via sea routes. Marine transport remains by far the most cost-effective way to move goods and raw materials around the world. The cost of marine transport averages around \$1,000 per metric ton, compared to around \$2,000 per ton over land and \$50,000 per ton for air transport (excluding intra-EU trade). In 2017, 10.7 billion tons of goods were loaded and discharged and 753 million twenty-foot equivalent units (TEUs) of containers were handled in ports worldwide. This comprised about 30% oil and gas, 30% bulk commodities such as coal and iron ore, and the remaining roughly 40% other dry cargo. The statistics quoted thus far are physical freight volumes—it is harder to get an accu-

[1] The *International Maritime Organization* regulation requires AIS to be fitted aboard all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages, and all passenger ships irrespective of size. The requirement became effective for all ships by December 31, 2004.

rate figure on the maritime freight transport share of world trade value with estimates around 70% (Figure 4).

Figure 4: Share of global trade by mode, volume and value (2017)



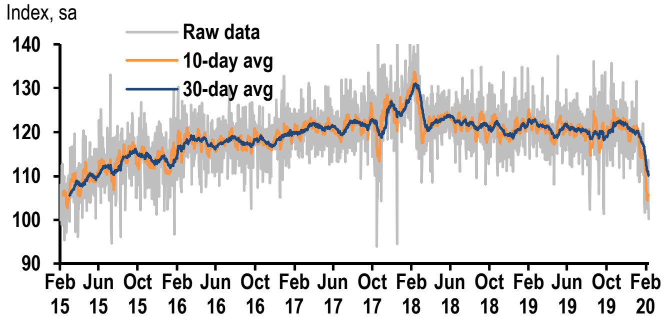
Source: UNCTAD, IATA, J.P.Morgan estimates

Introducing the daily and monthly J.P. Morgan Big Data Shipping Index (BIDSI)

Through processing and filtering, the database we use systematically identifies and tracks the worldwide movements of over 50,000 commercial ships among 7,500 ports. Over 100,000 individual cargo movements (load/unload) are captured every month. Using this, we can create region- and country-level data at daily intervals. Figure 5 shows the aggregated global version of the J.P. Morgan Big Data Shipping Index (JPM BIDSI)—a daily series of global shipping volume. Our global BIDSI represents goods volumes transported via sea routes for 198 countries. As expected, the daily data are very noisy, hence, we constructed 10- and 30-day rolling average series.[2] We also constructed an aggregate monthly BIDSI to ease comparison with other monthly indicators.

Figure 5: J.P. Morgan Big Data Shipping Index - Daily Global

Index, sa



Source: J.P. Morgan, MariTrace

The main benefit of our BIDSI is that we are able to obtain data much earlier than figures from official sources, with initial data coming in with only a one day lag, compared to at least a week (for only a handful of countries that report high frequency data). Official external trade data are not available from most countries until several months after the end of the reference month (Table 1).

Table 1: Delay in obtaining global trade statistics

Time from end of the reference period until data release

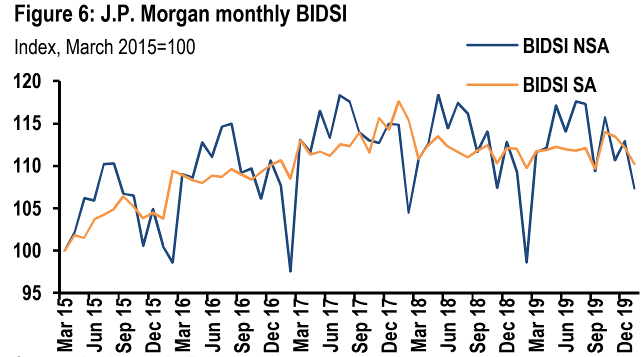
Source	Time lag
IMF DOTS trade data	3-4 months
ITC Trade Map	1-4 months
CPB World Trade Monitor volume data	2 months
RWI Global container index	1 month
National statistics	1-2 months
Preliminary trade reports*	1 week
JPM Big Data Shipping Index (BIDSI)	One day

Source: J.P. Morgan. *Brazil and Korea release flash trade prints.

While the daily series are useful for real-time tracking of activity, we also construct a monthly BIDSI series to compare with traditional monthly activity indicators such as IP (Figure 6). In addition to the raw BIDSI series, we also compute a seasonally-adjusted BIDSI by detrending the average monthly seasonal factors.

Figure 6: J.P. Morgan monthly BIDSI

Index, March 2015=100



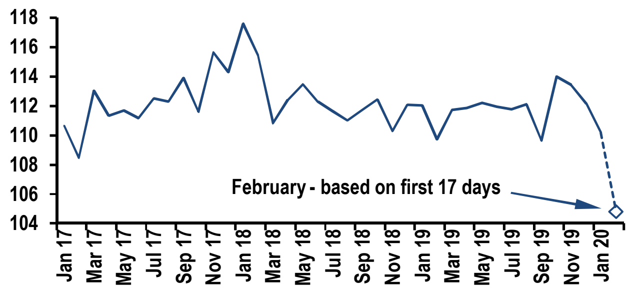
Source: J.P. Morgan, MariTrace

More important, we find that the variation within any month tends to be low, therefore early readings partway through the month provide good estimates of the full-month figures. With data through February 17, our BIDSI suggests that global shipping trade slowed substantially in seasonally adjusted terms, likely driven by China factory shutdowns and COVID-19-related transport disruptions (Figure 7). It extends the trend decline in global shipping volumes seen since the end of 2017 when the US-China trade war started to escalate. We will look for an upturn in the index as an early signal that the growth shock from the coronavirus has faded.

[2] We use STL (Seasonal and Trend decomposition using Loess) to adjust for seasonal effects. We note there are more advanced methods of dealing with daily data – see "*It's a mess, ain't it? Dealing with daily data,*" GDW, *Jesse Edgerton.*

Figure 7: JPM monthly BIDSI

Index, sa, Mar 2015=100; data as of Feb 17



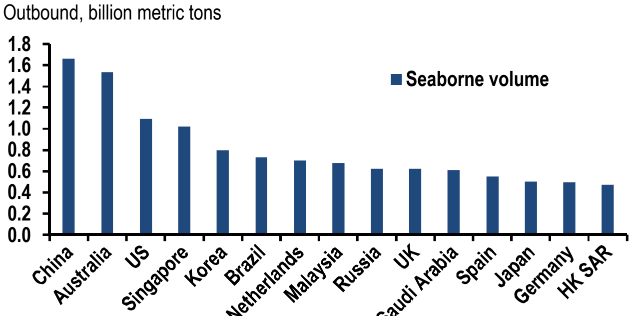
Source: J.P. Morgan, MariTrace

While the BIDSI is expressed in volume terms, the raw data have properties of a throughput-type metric based on the flow of ships through ports with each completed shipping movement typically spanning several months and the supply of shipping vessels relatively fixed (it takes around two years to build a container ship).

Looking at the subcomponents of the BIDSI, we are able to zero in on country-level shipping flows by focusing on either inbound (imports) or outbound (exports) shipping traffic. Within each subcomponent we can include or exclude intra-country (domestic) trade flows. For the headline BIDSI, we include intra-country flows as a measure of activity. However, when looking at inter-country trade, we exclude the intra-country flows. This distinction is particularly important when looking at a country that has large amounts of intra-country trade (e.g., China). In Figure 8, we lay out the top 15 countries by outbound seaborne trade volume; unsurprisingly, the majority of the top EM exporters are from EM Asia. At the country level, there are some timing issues with the data—e.g., an outbound ship leaving the US would be recorded as an export immediately, but would not be recorded as an import until it arrives at the destination (which could be more than a month later).

Figure 8: Top countries by outbound shipping volume (2019)

Outbound, billion metric tons



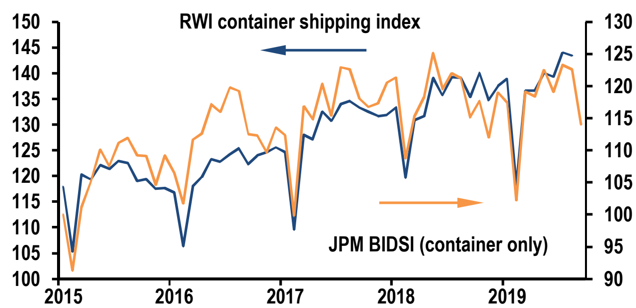
Source: J.P. Morgan. Maridata. Excludes domestic flows.

Have all the ships sailed? How does the BIDSI perform?

In this section, we compare the BIDSI with widely-used high-frequency indicators of global shipping trade activity and find that it tracks these quite well in addition to having a number of superior properties. The most obvious point of reference is the RWI/ISL global container throughput index—its aim is to provide timely information on short-term trends in international trade. While this measure only covers container shipping (about 17% of seaborne trade), we can replicate the sample by restricting our vessel tracking to container ships only. Figure 9 shows that our BIDSI tracks the RWI/ISL index well. Moreover, the BIDSI is broader in its coverage and timelier than the RWI. Whereas the RWI global shipping container index captures activity through roughly 85 container ports (two-thirds of global activity) and is released about one month after the end of the reference month, our BIDSI captures 100% of ports and is updated daily.

Figure 9: Global container ship throughput vs. BIDSI

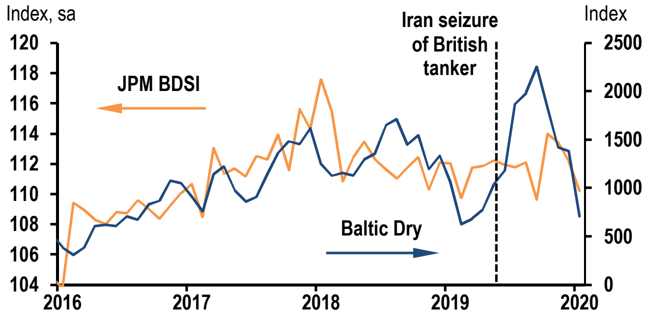
Index, nsa, both scales



Source: J.P. Morgan, Maridata, RWI/ISL, Haver.

The Baltic Dry Index (BDI) is another often-used gauge of global economic activity and is seen to be a leading indicator given that dry bulk cargo is predominantly raw materials used for construction and industry. However, the BDI is actually an index of container shipping costs. The supply of cargo ships is extremely inelastic due to high build costs and lead time. Hence, fluctuations in demand can typically be captured by changes in price. A weakness of the BDI then is that events unrelated to global demand can cause large changes in shipping prices; for example, the temporary supply shock caused by the seizure of a British oil tanker by Iran corresponded with a jump in BDI over July-August 2019, despite trade volumes staying quite flat (Figure 10). Because our BIDSI directly measures shipping traffic, it provides a more accurate gauge of underlying supply and demand factors driving global trade activity and is unaffected by short-term or speculative price changes.

Figure 10: Baltic Dry vs. JPM BIDSI



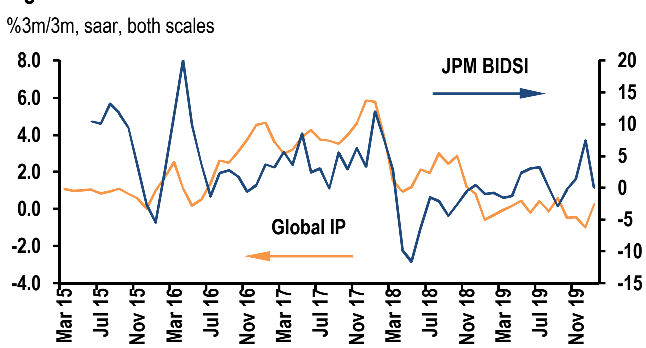
Source: J.P. Morgan

In sum, the BIDSI beats the RWI on coverage and timeliness and is immune to the price distortion issues that have at times affected the BDI. Further, the BIDSI goes beyond just a headline activity indicator like the BDI and RWI, as it can be decomposed by region, country, and in some cases commodity.

Shipping index delivers the goods for EM

Given the large share of shipping transport in global trade, by accurately capturing marine trade, we have the potential to not only improve our tracking of merchandise trade flows but also obtain early signals on real activity such as manufacturing output. Starting with global IP, we find that the BIDSI captures some of the turning points in the global IP data (Figure 11).

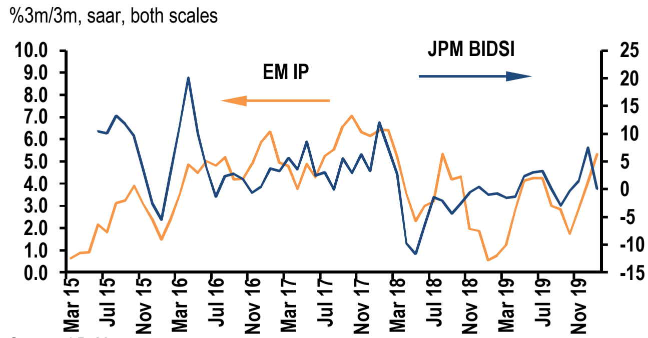
Figure 11: Global IP vs JPM BIDSI - Global



Source: J.P. Morgan

Due to the more significant role of trade in EM economies and the lack of viable alternatives (air transport is prohibitively expensive in some EM countries and land infrastructure is not set up) it follows that we should look deeper into the relationship of our shipping index with EM activity. On visual inspection, the BIDSI appears to capture EM manufacturing growth momentum somewhat better than it does global manufacturing growth (Figure 12).

Figure 12: EM IP vs. JPM BIDSI



Source: J.P. Morgan

But how does our BIDSI compare to other early indicators of manufacturing output? We compared a variety of different regressions using our BIDSI and the PMI to gauge its ability to track at both at the global and EM aggregate level. Although it does not provide much formal explanatory power for global IP, we find that the BIDSI stands out and does much better than the PMI in terms of tracking EM manufacturing. As shown in Table 4, the BIDSI explains more of the variation in EM than the PMI (equation ii). Moreover, including both the PMI and BIDSI in the same equation still point to a greater significance level for the BIDSI (equation iv).

Table 4: Multivariate regression analysis with BIDSI

Dependent Variable: EM IP mfg %m/m, sa; period: Mar 2015 to Dec 2019

	i	ii	iii	iv
Constant	0.5	-3.0	0.5	-3.2
	***		***	**
Lagged IP	-0.4	-0.5	-0.4	-0.5
	***	***	***	***
PMI output (EM)		0.1		0.1
		*		**
BIDSI (log diff)			7.13	7.52
			***	***
Adj-Rsq	0.17	0.20	0.25	0.33
Std err of reg	0.37	0.36	0.35	0.33

Source: J.P. Morgan. Significance level: 1% (***), 5% (**), and 10% (*).

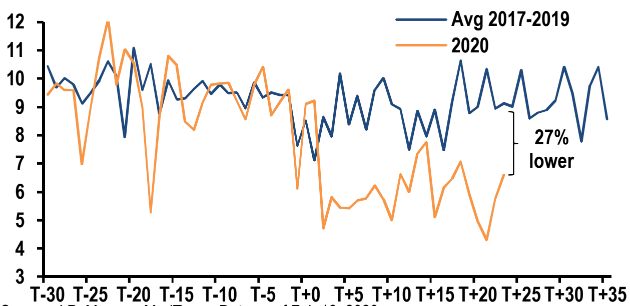
First port of call: tracking the impact of COVID-19 with the JPM BIDSI

One of the best uses for the JPM BIDSI is to track large-scale macro events that impact economic activity, in particular, via trade. The COVID-19 outbreak is one such event. Using the country-level tracking of shipping flows, we focus on inbound flows to Chinese ports to assess the scale of transport disruptions. Due to the Lunar New Year impact, we center the data on the days surrounding LNY (Figure 13). We find that shipping imports fell sharply on January 27 this year, coinciding with the factory shutdowns across China.

Currently, our BIDSI only captures each ship's first port of call: e.g., if a ship transports 50 tons of cargo from Brazil and places 10 tons in Shanghai and the other 40 tons in Qingdao, it would be counted as a flow of 10 tons from Brazil to China. The remaining 40 tons are counted as a China-to-China flow.

Figure 13: China BIDSI inbound

Inbound - million metric tons per day; centered on Lunar New Year

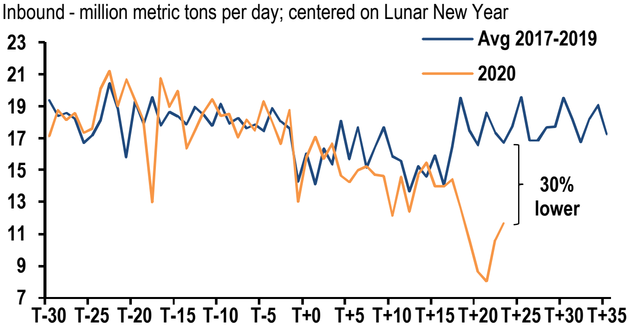


Source: J.P. Morgan, MariTrace. Data as of Feb 18, 2020

To capture a more representative picture of trade activity, we augment our China BIDSI inbound data by including China-to China (domestic) flows. In Figure 14, we can see that the fall in overall inbound activity only started to materially fall a week or so ago. It suggests that many foreign ships stopped arriving at Chinese shores many weeks ago, but domestic shipping activity continued at a steady pace comparable to the historical average until about a week ago.

Figure 14: China BIDSI inbound inc. domestic flows

Inbound - million metric tons per day; centered on Lunar New Year

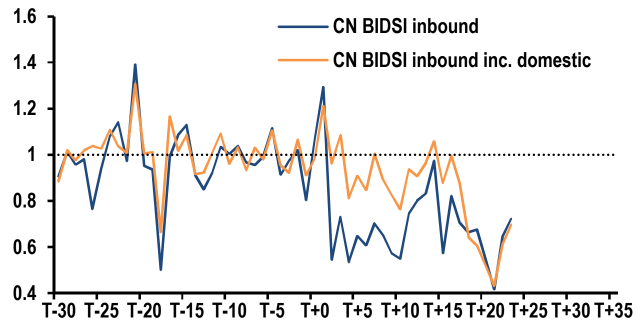


Source: J.P. Morgan, MariTrace. Data as of Feb 18, 2020

This difference in timing of the drop-off in trade activity between the international (inbound only) and overall trade activity (including intra-China) is clearer when the two series are shown as a ratio relative to their respective historical averages (Figure 15).

Figure 15: CN BIDSI inbound vs CN BIDSI inbound inc. domestic

Ratio; relative to historical average, centered on Lunar New Year

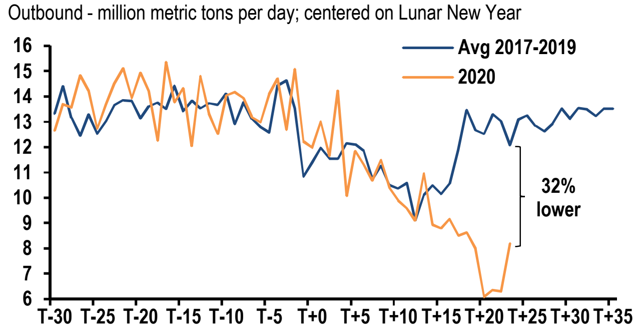


Source: J.P. Morgan, MariTrace. Data as of Feb 18, 2020

Last, we look at the China BIDSI outbound series—including domestic flows—as an indicator of Chinese outbound trade activity (Figure 16). The picture here is very similar to the BIDSI inbound activity series. We see a clear divergence in this year's outbound activity starting around 13 days after LNY (Feb 7). In cumulative terms, inbound and outbound activity are both running around 30% lower since LNY relative to the historical average.

Figure 16: China BIDSI outbound inc. domestic flows

Outbound - million metric tons per day; centered on Lunar New Year



Source: J.P. Morgan, MariTrace. Data as of Feb 18, 2020

Navigating choppy data: Unbundling AIS as alternative data source for trade flows

Nowadays, vessels worldwide can be tracked in almost real time. Cargo ships are equipped with a device (transponder) that periodically sends a radio signal (an Automatic Identification System message, or AIS) that contains information on the vessel's location, speed, destination, draught, and other information. The AIS is an autonomous tracking system that is extensively used globally for the exchange of navigational information between AIS-equipped terminals (e.g., other vessels or coastal authorities).

A quick walkthrough of AIS:

The AIS information transmitted by a ship contains three basic sections:

• ***Dynamic information***; which, apart from "Navigational status" information, is automatically updated by the onboard sensors connected to the AIS; these include the Maritime Mobile Service Identity number (MMSI)—a unique identification number from which a vessel's flag can also be identified—and the speed, course, rate of turn, and position coordinates of the vessel.

• ***Static information***; which is entered into the AIS on installation and needs to be changed only if the ship changes its name or undergoes a major conversion from one type to another; this includes —name, vessel type, and dimensions.

• ***Voyage-related***; information that is provided by the vessel's crew and need to be manually entered and updated during the voyage. These include the vessel's draught, destination, and estimated time of arrival.

Table 2: AIS information transmitted by a ship

Name	Description	Example	Units	Resolution
MMSI	Maritime Mobile Service Identity	477549878	-	-
BaseDateTime	Full UTC date and time	20170201T20:05:07	-	YYYY-MM-DD:HH-MM-SS
LAT	Latitude	42.35137	decimal degrees	XX.XXXXX
LON	Longitude	-71.0418	decimal degrees	XXX.XXXXX
SOG	Speed Over Ground	5.9	knots	XXX.X
COG	Course Over Ground	47.5	degrees	XXX.X
Heading	True heading angle	45.1	degrees	XXX.X
VesselName	Name as shown on station radio license	OOCL Malaysia	-	-
IMO	International Maritime Organization Vessel number	IMO962798	-	-
CallSign	Call sign as assigned by FCC	VRME7	-	-
VesselType	as defined in NAIS specifications	70	-	-
Status	Navigation status	Active	-	-
Length	Length of vessel	71	meters	XXX.X
Width	Width of vessel	12	meters	XXX.X
Draft	Draft depth of vessel	3.5	meters	XXX.X
Cargo	Cargo type	70	-	-
Transceiver Class	Class of AIS transceiver	AIS Class A	-	-

Source: National Oceanic and Atmospheric Administration, J.P. Morgan

How frequent and big is AIS? Around the world in a billion data points a day

The global AIS network receives more than a billion position or status updates per day from various sources around the world. While moving, a vessel broadcasts its position via AIS every 2-30 seconds, meaning that these vessels broadcast thousands of messages per day received either via satellites or by terrestrial antennas (Table 3).

Table 3: Types of AIS transponders and corresponding vessel status

Transponder type	Vessel status	AIS transmission rate
Class A	Anchored / Moored	Every 3 minutes
Class A	Sailing 0-14 knots	Every 10 seconds
Class A	Sailing 14-23 knots	Every 6 seconds
Class A	Sailing 0-14 knots and changing course	Every 3 seconds
Class A	Sailing 14-23 knots and changing course	Every 2 seconds
Class A	Sailing faster than 23 knots	Every 2 seconds
Class A	Sailing faster than 23 knots and changing course	Every 2 seconds
Class B	Stopped or sailing up to 2 knots	Every 3 minutes
Class B	Sailing faster than 2 knots	Every 30 seconds

Source: National Oceanic and Atmospheric Administration and MarineTraffic

Around 165,000 unique ships are recorded by AIS at any one time, and in total these ships generate an estimated 19,000 AIS messages per second with a data generation rate of 48MB a second—resulting in approx. 1.6 billion AIS messages or over 4 terabytes of data a day (4.1 million MB).

Even with sophisticated computing resources, it would be challenging to work with such an enormous dataset, particularly if we wanted to track it over time. Another issue is that the raw data are too noisy to be used without further processing. The nature of harvesting raw AIS data in volume can create significant data consistency issues, which require careful data cleaning and processing. Moreover, we must bear in mind that the source data were not designed for this purpose and may include significant data inconsistencies. First, let's look at what AIS can show us to see whether it can be useful.

Sailing the Seven Seas: Global coverage of AIS tracking

When a snapshot of the current location of active vessels—separated by ship type—is plotted on a world map using AIS, we can quickly see how vast the coverage of the AIS network is (Figure 17). Certainly, there are instances where a vessel will "go dark," where the AIS network does not receive a signal. This can be intentional—when the vessel in question may be undertaking nefarious activity and tries to avoid detection—or unintentional, for example, due to a weak transmission signal or interference. But these incidents are relatively uncommon as they likely attract investigation by au-

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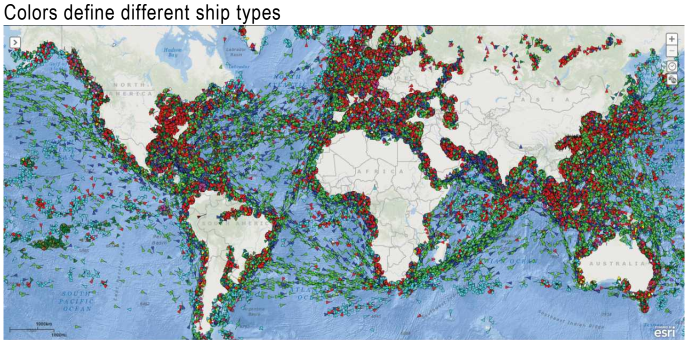
thorities and get resolved quickly as ships rely on AIS to avoid collisions on busy shipping routes.

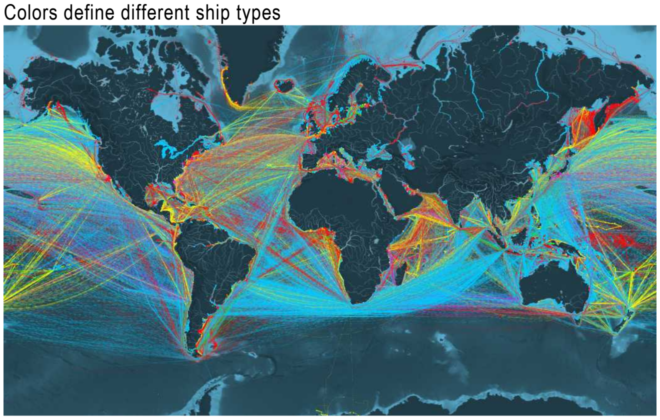
Figure 17: Snapshot of current location of active vessels
Colors define different ship types



Source: esri (ExactEarth)

With the static snapshot of the AIS network data quite comprehensive, we turn to look at how we can use AIS to look at the shipping movements (Figure 18). We find that shipping routes tend to be well defined particularly when considering vessel type. For example, passenger/leisure ships may take unpredictable routes, whereas container ships would tend to stay on similar shipping routes year after year.

Figure 18: Visualization of global shipping routes
Colors define different ship types

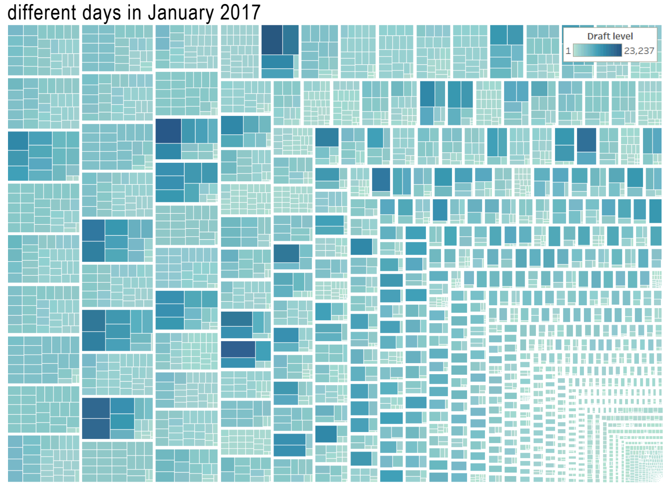


Source: Kiln (https://www.shipmap.org/)

The ability to filter the data by vessel type allows us to narrow down the dataset to show only container, tanker, and other cargo ships that are relevant for international trade. Furthermore, detailed vessel subtype information combined with port-level data (such as which dock/berth a particular ship uses) can enable us to trace ships that carry certain commodities (e.g., coal, iron ore, and crude oil). Hence, AIS-based data can potentially present a rich picture of international trade by providing information on real-time positions of vessels that can be used to create daily trade data. However, AIS does not directly provide information on the cargo of each vessel (i.e., what exactly is being carried) or the quantity of cargo (i.e., how much is being carried).

AIS does capture information on the current draught—the waterline of the sea on the ship's hull—of the ship. We can use this data in combination with the static information of the vessel (dimensions, gross weight, etc.) to infer the weight of the cargo being transported. In particular, the change in the draught (before and after a port visit) will give information on the net volume of cargo that was loaded or unloaded at each port visit, which should correspond with exports and imports. Figure 19 shows the draught data in a handful of US-based AIS terminal zones (six out of 20 zones), comprising nearly 4,000 changes in draught level made by 978 unique vessels in January 2017.

Figure 19: Changes in draught captured by AIS terminals at selected US ports in one month
Each large rectangle denotes a ship and colours within show draught level on different days in January 2017



Source: J.P. Morgan, U.S. National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management and the U.S. Bureau of Ocean Energy Management (BOEM) (https://marinecadastre.gov) – file size: 460MB

What floats your boat? Archimedes' principle to deduce vessel tonnage and shipping trade flows

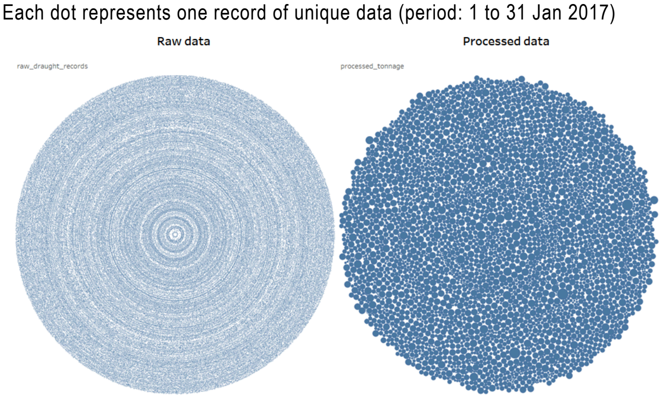
According to Archimedes' principle, the displacement of the vessel for a certain draught is equivalent to the weight of the vessel, which includes: the lightweight (empty shell) of the ship, cargo, ballast, crew, fuel, and other provisions. Thus, in principle, using the dimensions and information of non-cargo masses and assuming still-water conditions—which a docked ship usually has—it is possible to transform the observed draught value into an estimated payload (or net tonnage). Once we combine the estimated payload with the AIS movement data we can build a usable database of high-frequency and reliable shipping trade flows.

Creating the trade flow database comprises six main stages:

1. **Collection of raw data:**[3] Movement (via AIS for positioning and draught) + ship design (to be used in models to calculate tonnage accurately) + berth data (to obtain commodity-level data).

2. **Processing and filtering of the data into usable form:** Due to the size enormity of the raw data set, the data must be cleaned and filtered. One approach is to concentrate the data gathering only in areas of interest—in this case, only when a ship (excluding military and passenger) is entering or leaving a port and draught data are the main pieces of information we need. Furthermore, while the raw data are recorded every second, taking the data at a daily level is sufficient for our purposes. As an example, in Figure 20, out of 218,689,038 unique records in the original raw data (sample from US-based AIS in the month of January 2017) only 8,982 were relevant for the processed data.

Figure 20: Raw data vs. processed data
Each dot represents one record of unique data (period: 1 to 31 Jan 2017)



Source: J.P. Morgan, U.S. National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management and the U.S. Bureau of Ocean Energy Management (BOEM) (https://marinecadastre.gov)

3. **Vessel-level calculation:** At the granular level, the payload of each ship must be estimated using a mathematical model (such as variable lightweight method; see Appendix) with which vessels' design data like block coefficient, length, and width and also AIS/satellite data like draught, longitude/latitude, and current movement status are used to derive the estimated payload (net tonnage) of a particular vessel. Figure 21 shows a snippet of example python code to calculate vessel-level tonnage.

Figure 21: Example python code to calculate vessel level tonnage

```
# beam calculation
def beam calculation(LOA):
    """calculation of the beam"""
    beam = LOA**(2/3)
    return beam

# block coefficient at operation calc

def current_block(Cbd, Td, T):
    """calculates the operational block coefficient function
    of the design block coefficient, reference draught an current draught"""
    current_block = 1-(1-Cbd)*(Td/T)**(1/3)
    return current_block

# calculate the current payload
def payload (Cbd, Cb, L, B, P, Td, T):
    """calculates the payload using draught, design data and previous draught"""
    payload = Cb*L*B*P*T - Cbd*L*B*P*Td
    return payload
```

Source: J.P. Morgan

4. **Combining with movement data to create global database of shipping flows:** With each vessel's payload estimated, it is combined with AIS movement data. For example, if a vessel leaves Porto Da Madeira, Brazil, to Bayuquan, China, with a reduction in payload of 200 metric tons, it is recorded in the database as an export of 200 metric tons from Brazil to China.

5. **Additional data from other sources are incorporated to further improve accuracy and granularity of the data.** We can find/deduce the commodity loaded at the port by looking at berth (docking station at the port) information—for example, some berths can only load and unload coal—found via satellite imagery or port authority reports. These data can be processed and combined with the above steps to add information on the exact commodities carried on each vessel/trade route.

6. **The final stage is aggregating the cargo movements for any trade route to create a database of the world's shipping trade.** We source this database from MariTrace, which has data extending back to January 2015.

Next port of call: Areas of further research

Our initial analysis has shown that our Big Data Shipping Index tracks global shipping volumes in a timelier fashion than and in some cases outperforms "traditional" data. Events such as the US-China trade war and COVID-19-related disruptions have only increased the focus on tracking global trade flows. As a next step, we will look to expand our analysis to trade tracking for individual countries, delve deeper into commodity-level shipping data, and explore topical issues (see case studies in Appendix).

[3] Note: the raw tonnage and flow figures used in this note are provided by MariTrace.

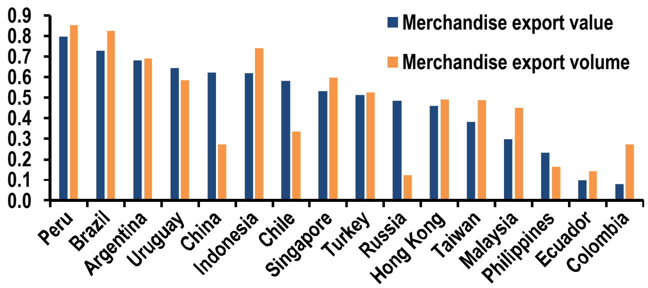
Appendix 1: Which countries next?

As the BIDSI directly measures seaborne trade volumes it should be a useful measure of overall export and import volumes especially for countries that rely on shipping as their main mode of international trade. Possessing high-frequency and short lag data is particularly well-suited to tracking and estimating EM data given that many countries tend to suffer from data quality and timeliness issues. Moreover customs data are often prone to revision.

To narrow down the suitable countries in a more systematic way, we look at a correlation matrix between our BIDSI and official customs export data in value and, where available, volume. Figure 22 suggests that Latin American countries would be most suitable for country-level analysis.

Figure 22: JPM Big Data Shipping Index vs. exports

Correlation between BIDSI and total exports from official sources (monthly)



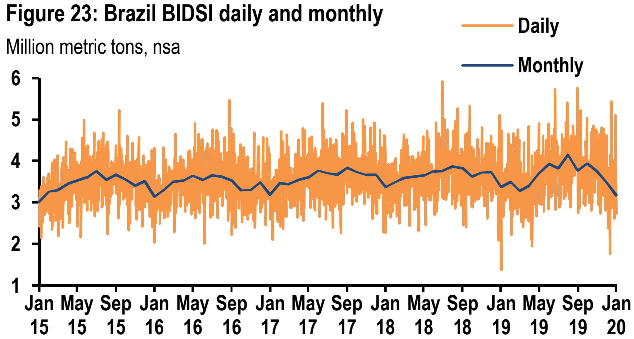
Source: J.P. Morgan, Maridata, Haver. No volume data for Mexico, India or Poland.

Appendix 2: EM country level BIDSI

Based on our database, China is consistently the largest EM exporter via marine transport, while Ecuador is the smallest (excluding landlocked countries). The country-level daily data are very noisy, but we can use statistical techniques to smooth and clean the data or aggregate the data into weeks or months. As an example, we chart Brazil daily exports with the monthly average in Figure 23.

Figure 23: Brazil BIDSI daily and monthly

Million metric tons, nsa



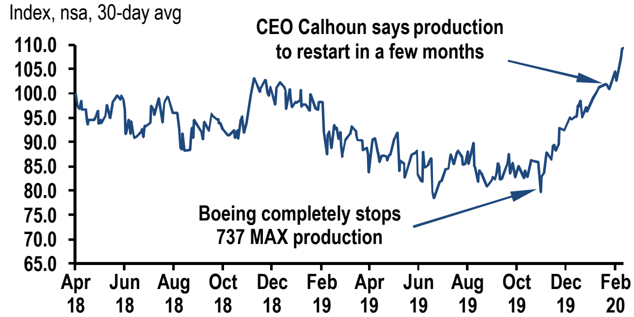
Source: J.P. Morgan, MariTrace

Appendix 3: Boeing 737 MAX case study

With the correct parameters, we can focus our database to narrow down on specific ports in the world. As a case study, we look at the volume of shipping imports (from Japan) through the ports of Tacoma and Seattle (Figure 24), which Boeing uses to import parts from Japan to build airplanes. While we can see a fall in volumes, we cannot be certain the decline can be attributed to Boeing supply lines without additional research on the data. Nevertheless, the ability to narrow down at such a granular level opens up more avenues to look at global trade.

Figure 24: Shipping imports from Japan to Tacoma and Seattle, USA

Index, nsa, 30-day avg



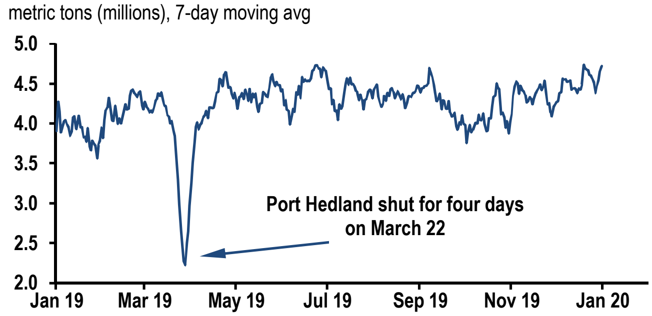
Source: J.P. Morgan, MariTrace, Bloomberg News

Appendix 4: Cyclone Veronica case study

Tropical Cyclone Veronica hit Australia in March 2019. In preparation for the passage of Veronica, major shipping ports were shut down. Port Hedland, the most valuable export hub in Australia and one of the largest iron ore loading ports in the world, was closed March 22-26 (Figure 25).

Figure 25: Australia BIDSI

metric tons (millions), 7-day moving avg



Source: J.P. Morgan, MariTrace

Appendix 5 – Calculating net tonnage

Note: the tonnage data used in this note are provided by MariTrace. The below shows the general principles.

Variable lightweight method to calculate payload (net tonnage):

Given that total displacement of a vessel is the sum of its deadweight (*DWT*) and lightweight (*LWT*), it follows that we can calculate lightweight as:

$$LWT = C_{bd}.L.B.T_{d}.\rho - DWT$$

Where:

C_{bd} is the vessel's block coefficient (the ratio of a ship's volumetric displacement to the volume of a cuboid of sides equal to the ship's length, beam and draught) at its design state

L is the length overall in meters

B is the beam (width) in meters

T_d is the vessel's draught in meters.

ρ is the density of the water (Seawater is denser than fresh water, so a ship will ride higher in salt water than in fresh)

When we observe the vessel during operation at a draught of T, the payload (π_v) or cargo onboard can be estimated as:

$$\text{Net tonnage } (\pi_v) = C_b.L.B.T.\rho - LWT$$

Block Coefficient (C_b):

C_b, is the block coefficient during operation at draught T, which can be approximated according to basic principles of ship propulsion.

$$C_b = 1 - (1 - C_{bd})\left(\frac{T_d}{T}\right)^{\frac{1}{3}}$$

Upon substituting the required values, one can estimate the payload of the ship. C_{bd} has been inputted as per Kristensen's statistical relationship with lightweight and a vessel's dimensions.

Source: J.P. Morgan and Centre for Marine Technology and Ocean Engineering (Portugal), *"Estimation Methods for Basic Ship Design"*

Appendix 6 - AIS, ship and berth data

Here is the example from the source data using the Vessel IMO as a unique identifier:

AIS/SATELLITE DATABASE:

VESSEL_IMO	9738210
SHIPNAME	STAR EOS
TIMESTAMP	16/11/2019 00:29:31
LON	118.0762
LAT	38.4354
ETA	11/29/2019 14:00
CURRENT DRAUGHT	12
DESTINATION	PORT OF BALBOA
ORIGIN	PRINCE RUPERT
STATUS	UNDER WAY USING ENGINE

SHIP DESIGN DATABASE:

VESSEL_IMO	9738210
SHIPNAME	STAR EOS
DRAUGHT_MIN	9
DRAUGHT_MAX	15
LENGTH OVERALL	400
BEAM	54
SHIPTYPE	BULK CARRIER
BLOCK COEFFICIENT	0.64

BERTH DATABASE:

VESSEL_IMO	9738210
SHIPNAME	STAR EOS
START BERTH NAME	SBN ANCHORAGE
END BERTH NAME	EBN ANCHORAGE
COMMODITY	CEMENT

Source: FleetMon

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