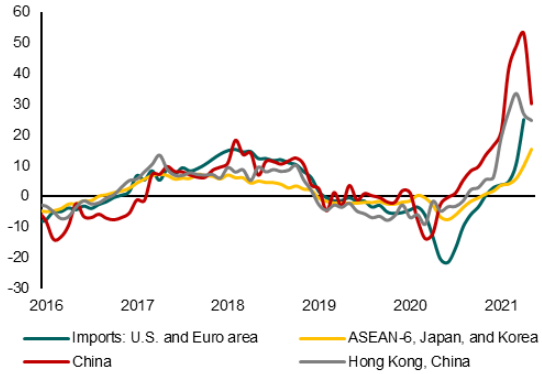
Covid Congestion and Trade Fever in the ASEAN+3: A Prognosis with the Shipping "Crystal Ball"[1]

July 2, 2021

I. Introduction

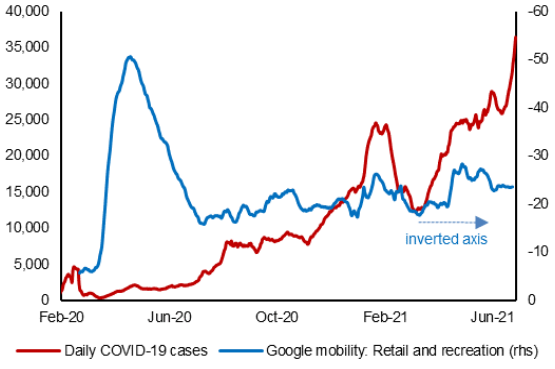
1. **Merchandise exports from the ASEAN+3 economies have been a bright spot in the economic recovery from the COVID-19 pandemic**. The region's exports were quick to rebound after stringent containment measures were eased in the first half of 2020; by year-end, most ASEAN+3 exports had well exceeded their pre-COVID-19 levels (Figure 1). The turnaround further strengthened in the first five months of 2021, largely supported by fast-growing demand from the United States and Europe. As a result, buoyant external demand has helped offset the continuing weakness in the region's domestic economies, which continue to be held back by movement curbs against resurgent waves of COVID-19 infections (Figure 2).

Figure 1. Merchandise Exports from ASEAN+3 versus Merchandise Imports from U.S. and Euro Area
(Percent year-on-year, 3 month moving average)



Sources: National authorities via Haver Analytics, AMRO staff calculations.
Note: ASEAN-6 refers to Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.

Figure 2. ASEAN+3: Daily COVID-19 Cases and Mobility Trends
(Number; percent)



Sources: Google LLC; Johns Hopkins University via CEIC; and AMRO staff calculations (data as of June 27, 2021).
Note: Both series are presented in terms of seven-day moving averages. The Google mobility indicator refers to the percentage change relative to a baseline, which in this case is the January 3–February 6, 2020 pre-pandemic period. Google mobility trends are unavailable for Brunei Darussalam and China.

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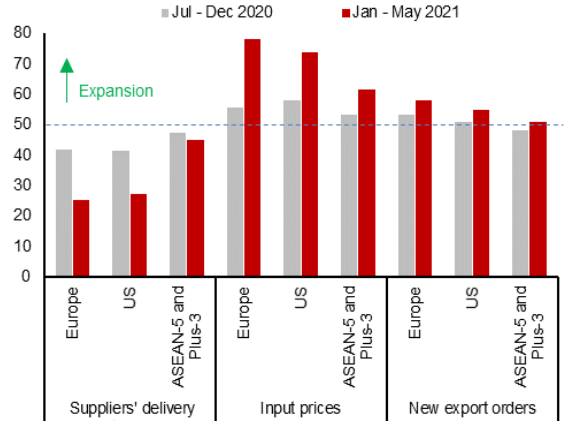
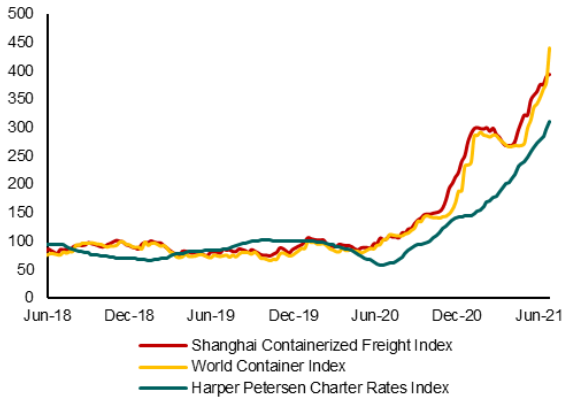
2. **However, the export rebound masks the continuing disruptions wreaked by the pandemic on global trade.** The upside surprise on ASEAN+3 exports—fueled by strong policy-induced demand in the advanced economies—has coincided with several economies still facing production and logistical constraints from COVID-19 containment measures (Figure 3). At major ports throughout the world, tight shipping capacity arising from reduced manpower, container supply imbalance, and a shortage of ships has led to congestion and a surge in shipping costs (Almendral 2021) (Figure 4). China—having brought COVID-19 infections under control sooner than its regional peers—has benefitted exceptionally from the surge in demand, but is nonetheless dealing with vessel delays at key ports owing to a shortage of containers. As a result, container freight rates from Shanghai—which hosts the world's busiest container port—have risen nearly fourfold since the end of 2019, with the blockage of the Suez Canal in March 2021 only adding to price pressures.

Figure 3. Purchasing Managers' Index—Manufacturing Sector
(Diffusion Index)



Sources: IHS Markit via Haver Analytics.
Note: ASEAN-5 refers to the average of the indices for Indonesia, Malaysia, Philippines, Thailand, and Vietnam. Plus-3 refers to China, Korea, and Japan; excludes Hong Kong, China owing to unavailable data. An index below (above) 50 means that a greater number of survey respondents report longer (shorter) delivery times, lower (higher) input prices, and lesser (more) new export orders.

Figure 4. Global Shipping Costs
(December 27, 2019 = 100)



Sources: Bloomberg Finance LP, Harper Peterson & Co., AMRO staff calculations.
Note: The Shanghai Containerized Freight Index reflects the spot shipping rates for 15 major container trade routes coming out of Shanghai. The World Container Index is a weighted average by volume of the spot container freight rates for eight major East-West trade routes. The Harper Petersen Charter Rates Index (or Harpex) is a composite of charter rate in U.S. dollar for nine different sizes of container ships. The three series are presented in weekly frequency, with June 25, 2021 as latest observation.

3. **Shipping constraints, as reflected in port congestions and a surge in freight rates, may threaten the recovery in global trade.** Maritime logistic impediments, in addition to the ongoing global semiconductor shortage, are expected to persist through the rest of 2021 (Konings and Luman 2021; Rockeman 2021; Yergin 2021). And, although air and land freight accelerated during the pandemic, maritime transport remains the backbone of global trade (UNCTAD 2018). Gridlocks at ports could leave ships stranded offshore for days, causing cargos to miss connecting ships or trucks to various destinations, and exporters to potentially lose customers overseas. At the same time, operational costs could build up, with the urgent need to meet strong demand from the West exacerbating cost pressures. Indeed, manufacturers in the ASEAN+3, Europe, and the United States have reported longer supplier delivery times and higher input costs amid an increase in export

orders in 2021 (Figure 4). The situation has raised concerns that supply bottlenecks could disrupt global trade (Oxford Analytica 2021; Steer and Wright 2020).

4. **This note analyzes the impact of port congestion in the ASEAN+3 economies on the region's trade.** As in del Rosario and Quách (2020), big data from the Automated Identification System (AIS)—a tracking system used by vessel traffic services that utilizes information collected from ship transceivers—are applied to this exercise. Two daily measures of port congestion for the 13 ASEAN+3 economies are derived;[2] they are validated by official trade statistics and media reports. The indicators are then used to gauge the impact of congestion on merchandise exports and imports across the regional economies.

II. Port Congestion Metrics for the ASEAN+3

5. **Maritime port congestion refers to the situation where ships are unable to load or unload their cargo as a result of full port capacity.** Such situations are associated with vessel delays and a general decline in port efficiency and productivity. Indicators used to assess operational efficiency, a component of overall port performance scorecards (UNCTAD 2016), include vessel turnaround time, cargo tonnage handled per vessel per day, and vessel waiting time to berth (UNCTAD 1976; Chung 1993).

6. **Two high-frequency indicators of port congestion are extracted from the AIS-based port call dataset.** From a large and complex AIS data feed, the structured port call data from MarineTraffic focuses only on vessel activity within a port. Alternative daily trade indicators are generated from this dataset using the filtering methodologies described in del Rosario and Quách (2020, 2021). The port call dataset is mined further to derive two daily indicators of port congestion namely: (1) vessel turnaround time; and (2) the number of delayed ships:

- ***Vessel turnaround time*** refers to the duration of a vessel's stay at port, and is calculated from its time of arrival to the time of departure. Given that a vessel's length of stay at port can vary depending on the type and amount of cargo being loaded or unloaded, port duration is computed for each vessel type (container, bulk carrier, or tanker). Moreover, vessels of the same type come in varying sizes, which, in turn, could affect their turnaround time.[3] To address the issue, the median daily turnaround time for each vessel type is estimated instead of the average, which may be influenced by the ship size distribution. The median also implicitly takes into account ship traffic, which could likewise affect turnaround time. The daily medians per vessel type are then averaged to transform the data to lower frequencies.

- ***Number of delayed ships*** is a count of vessels that stay longer than a particular vessel type's turnaround time during a normal period. The average of the daily median turnaround time for each vessel type in 2019 is defined as a "normal period" or pre-pandemic benchmark. Although not on the usual list of port performance

[2] Lao PDR is excluded from the exercise given that it is a landlocked country; the Savannakhet dry port does not host vessels and hence, does not contribute to the AIS.

[3] Containerships, for example, can be Feedermax (ships that can carry between 2,000–3,000 20-foot equivalent units or TEUs), Panamax (over 3,000 TEUs), neo-Panamax (over 10,000 TEUs or thereabouts), or post-Panamax/Ultra-Large Container Vessels (over 15,000 TEUs or thereabouts). UNCTAD (2020) presents approximate vessel-size groups per vessel type.

indicators, this metric is also referred to in analyst reports (Tyagi and Ng 2021). As a comparison, the data show that container ships stayed for about 18.6 hours at port in Singapore in 2019, and ranged from 8 hours for Japan to 52 hours for Myanmar.

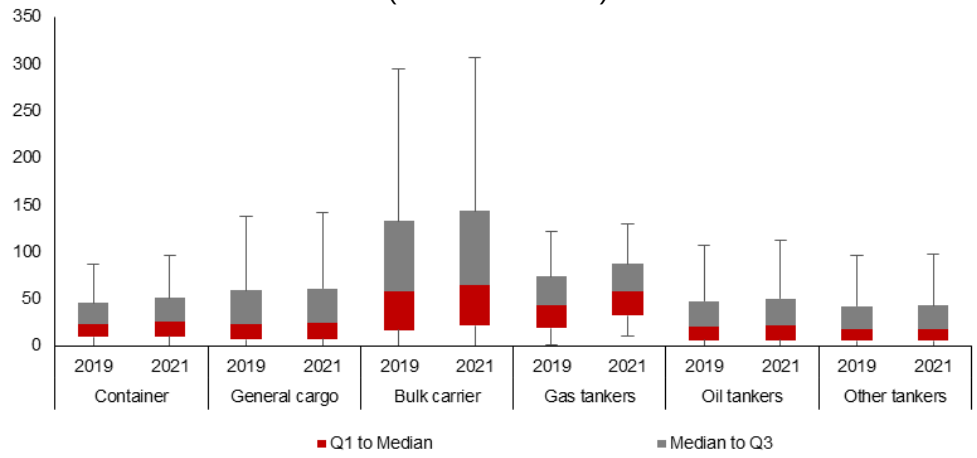
7. **Estimated vessel turnaround times provide evidence of congestion in ASEAN+3 ports across vessel types.** Container ships in the region's ports have reported higher median turnaround times, and wider spread—reflecting increased uncertainty in the timing of vessels' departure from port—in 2021 to-date, relative to 2019 (Figure 5). Bulk carriers and tankers also stay longer at ASEAN+3 ports relative to the pre-pandemic period. This development is in line with reports of tight capacity in dry bulk shipping in particular, reflecting increased demand for commodities (Miller 2021). Still, port situations in the region are better represented by container ships, which account for about 50 percent of the overseas-bound vessels from the ASEAN+3 region (Figure 6). Hence, the rest of the note will focus on container ship activity.

8. **There is a prevalence of (container) port congestion particularly among the region's major exporting economies.** The two port congestion indicators (vessel turnaround time and number of delayed ships), normalized based on average 2019 readings, show strong comovement in most cases. In particular, they have recorded higher readings from September 2020 through to the first semester of 2021 for China, Malaysia, the Philippines, Singapore, and Thailand, the majority of which are major exporters (Figure 7). The number of delayed ships at Thai ports rose further in March 2021 and diverged substantially from the vessel turnaround time, indicating a worsening case of port congestion around the time when exports picked up (Appendix I). Similarly, indicators for Hong Kong and Korea suggest greater shipping delays from April-June 2021 following months of steady increases in export momentum.

9. **Major ports in the ASEAN+3 economies are facing longer vessel turnaround times for the larger container ships that are likely to be involved in international trade.** For example, vessel stays have lengthened since end-2020 at the biggest Chinese ports of Shanghai and Shenzhen, and to a certain extent, Ningbo, Qingdao, and Nansha Guangzhou (Figure 8). These readings coincide with the pick-up in freight rates out of China toward the end of 2020, and are consistent with reports of congestion at key Chinese ports owing to an acute shortage of container equipment (Savvides 2020). Congestion at ports in Singapore, Korea (Busan), and Malaysia (Port Klang) have likewise been reported (Whelan 2021a). Overall, vessel delays have been observed for at least six months running at key container ports in China, Japan, Korea, Malaysia, and Thailand. More recently, major ports in Hong Kong, Indonesia, and the Philippines have also signaled longer vessel stays.[4]

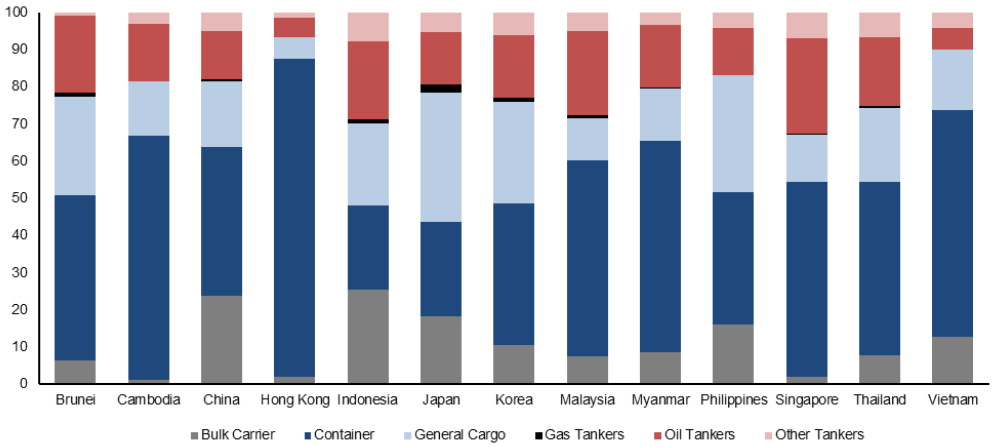
[4] Myanmar (Thilawa) also reported longer vessel turnaround times in April–June 2021, although delays do not appear to be driven by ship traffic and cargo volume—both of which have dropped sharply since the country was placed under a state of emergency on February 1, 2021.

Figure 5. ASEAN+3: Vessel Turnaround Time, by Vessel Type
(Number of Hours)



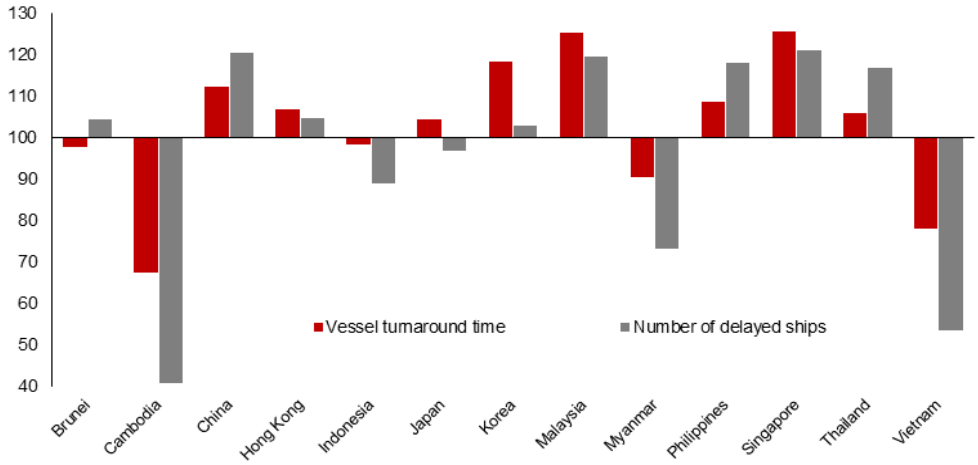
Sources: MarineTraffic; AMRO staff calculations.
Note: The top to bottom ends of the line represent 99.7 percent of the total number of ships by vessel type.

Figure 6. ASEAN+3: Distribution of Vessel Types, by Economy
(Percent of total)



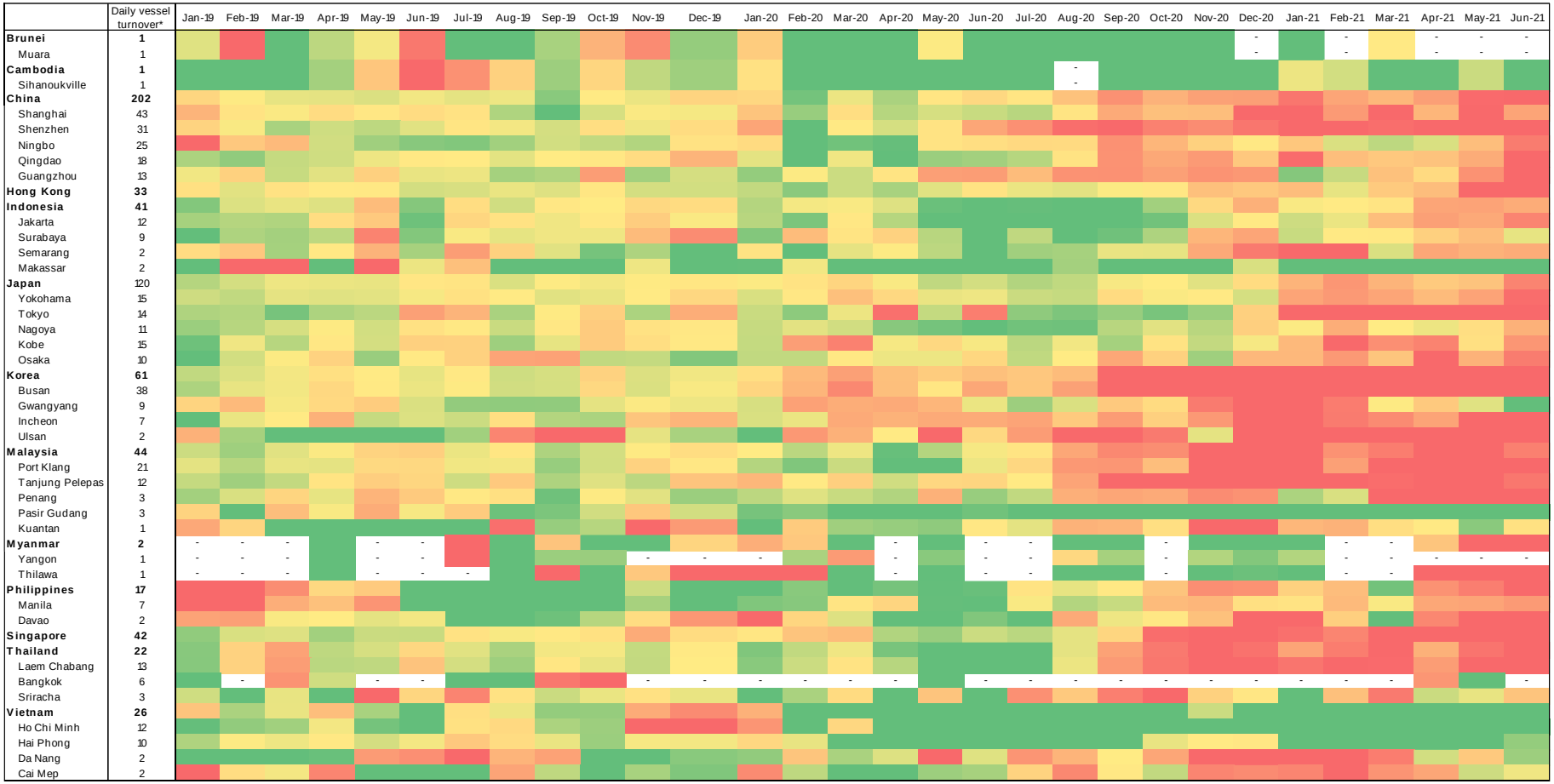
Sources: MarineTraffic, AMRO staff calculations.
Note: The above chart refers to overseas-bound vessels only and has been derived from a dataset of daily frequency covering the period January 2015–May 2021 for all ports in the ASEAN+3 region.

Figure 7. ASEAN+3: Maritime Port Congestion Indicators, Container Ships
(Percent, 2019=100; September 2020–June 2021 average)



Sources: MarineTraffic; AMRO staff calculations.
Note: The figures refer to container ships only.

Figure 8. ASEAN+3: Vessel Turnaround Time at Major Container Ports



Sources: MarineTraffic; AMRO staff calculations.

Notes: *Refers to the average number of container vessels that arrive and depart said port within a day from January 2019–June 2021 (as at June 27, 2021). Dashes (-) mean no container ship was recorded for the month. For the above heatmap, we have included only container ships with a carrying capacity of more than 2,000 TEUs, which tend to be involved in international trade. Red, Yellow, and Green refer to the 90th, 50th, and 10th percentiles, respectively, of the vessel turnaround time (in 2019=100) for the major ports in ASEAN+3 excluding Brunei, Cambodia, and Myanmar for the 2019-2021 period. **Shenzhen (China)** port comprises Da Chan Bay, Zhujian Kou, Chiwan, Shekou, and Yantian ports; **Guangzhou (China)** comprises Huangpu, MCID, Nansha, and Xinsha; **Busan (Korea)** combines both Busan and Busan New Port; and **Manila (Philippines) c**ombines both Manila and Manila South Harbor.

10. **Tight shipping capacity, coinciding with the speedy rebound in trade volumes, has led to freight delays and congestion at key ports in ASEAN+3 aside from China.** Insufficient containers are reportedly being brought back from Europe and the United States to Asia owing to weak import demand from this region (xChange). The shortage of containers in Asia is also being compounded by the lack of container ships, after international trade tensions and the COVID-19 pandemic dampened ship orders during the last three years. Moreover, disruptions to labor supply and port operations amid COVID-19-related movement curbs are adding to the pressure on shipping capacity to meet robust demand from the West (First 2021).[5] The following examples highlight developments at some of the key ports within the ASEAN+3:

- While major ports in China are facing a shortage of containers, Busan in **Korea** is dealing with large stockpiles attributed to the lack of container ships since the latter half of 2020 because vessels were diverted to China when it re-opened. The collapse of Hanjin Shipping Company in 2017, which cut down Korea's container shipping capacity by half, may have also exacerbated the shortage of container vessels in Korea (Kang 2021).

- In **Singapore**, strong export demand but insufficient containers to store cargo, in addition to a surge in vessel calls because ships were diverted from other ports due to logistical issues, has led to vessels clustering at the port (Tyagi and Ng 2021). The situation was also aggravated by the blockage of the Suez Canal in March 2021 (Hand 2021).

- Vessel delays in **Malaysia** (Port Klang) and **Thailand** (Laem Chabang) have likewise been caused by the shortage of container equipment as carriers reportedly prioritize capacity in China and Vietnam (Whelan 2021a, 2021b). In particular, container ships have been given precedence for the trans-Pacific routes, which have higher margins compared to intra-Asia routes.

- More recently, stalled operations at Yantian Port (Shenzhen, China) due to another COVID-19 outbreak also led to vessel diversions and worsening delays at other Chinese ports, including in **Hong Kong**, and further down to Southeast Asia, including **Indonesia** (Verma 2021).

III. Implications for ASEAN+3 Trade

11. **The port congestion indicators are mostly positively correlated with merchandise trade**. The relationships between the congestion indicators and both merchandise exports and imports are intuitive, given that reasonable increases in vessel turnaround times and the number of delayed ships could also be indicative of greater ship traffic and cargo volume (Table 1)—both of which are shown by del Rosario and Quách (2020, 2021) to track merchandise trade reasonably well. The correlations tend to be the highest among economies that are major participants in international trade, such as China, Hong Kong, Malaysia, and Singapore, with the high ship traffic in these economies likely enhancing the reliability of the AIS signals.

[5] Results of the econometric analysis by Attinasi, Bobasu, and Gerinovics (2021) show that the rise in shipping costs in Q4 2020 was largely a reflection of the strong recovery in global demand amid existing supply constraints in the shipping industry.

Table 1. ASEAN+3 excluding Lao PDR: Historical Correlations of the Port Congestion Indicators with Merchandise Trade, 2019–21
(Percent)

	Merchandise Exports in USD vs.		Merchandise Imports in USD vs.	
	Vessel Turnaround Time	Number of Delayed Ships	Vessel Turnaround Time	Number of Delayed Ships
Plus-3				
China	0.73	0.94	0.71	0.77
Hong Kong, China	0.65	0.69	0.72	0.73
Japan	0.19	0.47	0.38	0.69
Korea	-0.06	0.38	-0.04	0.54
ASEAN-5				
Indonesia	0.34	0.41	0.49	0.74
Malaysia	0.62	0.66	0.32	0.48
Philippines	0.04	0.33	0.07	0.21
Singapore	0.63	0.80	0.48	0.71
Thailand	0.33	0.56	0.39	0.51
BCMV				
Brunei Darussalam	0.10	0.13	0.07	0.26
Cambodia	0.18	0.17	0.13	0.16
Myanmar	0.20	0.16	0.00	0.62
Vietnam	-0.47	-0.42	-0.38	-0.29

Sources: MarineTraffic, AMRO staff calculations.
Notes: Green, Yellow, and Red refer to the 90th, 50th, and 10th percentiles, respectively, of the correlation coefficients for Plus-3 and ASEAN-5 for the 2019-2021 period. Port congestion indicators cover container ships only.

12. **However, greater levels of port congestion could also curtail trade.** While an increase in trade activity could push up port congestion metrics, a considerable rise in these indicators also appears to have a dampening effect on both exports and imports:

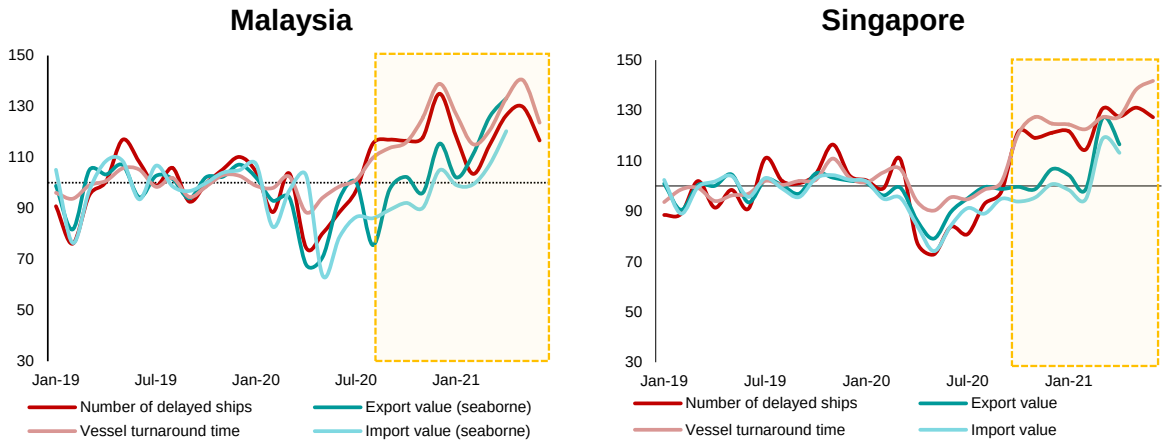
- The impact is evident for **Malaysia** and **Singapore** (Figure 9), and, to a certain extent, the **Philippines** and **Thailand**, where exports and imports have mostly lagged the increase in their respective congestion indicators since Q3 2020 (Appendix I). Further trade growth in each of these economies may have been held back by the lack of container equipment or ships, or both, which, in turn, led to port delays. Their port congestion metrics have jumped by as much as 30 percent over their 2019 averages. In this case, the port congestion metrics act as a proxy for timely container equipment data.

- Trade values have held up well in **China** despite a comparable increase in congestion indicators (Appendix Figure 1). However, import (and to a certain extent, export) volumes have also weakened since the second half of 2020 as the number of ship delays and vessel turnaround times rose. In particular, import volumes have lagged behind the increase in the number of delayed ships, suggesting the stifling impact of congestion on trade (Appendix Figure 2).

- **Vietnam** appears to have the best of both worlds—trade has grown robustly amid considerable improvement in port performance (Figure 10). The improvement appears to have been driven by the operation of new port terminals and increase in berth space (Labrut 2021a). That said, Vietnamese shippers are reportedly also dealing with container shortages and steep freight rates (Nguyen 2021). Data quality does not appear to be an issue given that alternative indicators—also derived from

the same AIS-based port call data—are consistent with the robust export outturn since November 2020 (Figure 11).

Figure 9. Malaysia and Singapore: Port Congestion Metrics vs. Trade Statistics
(Percent, 2019 = 100)



Sources: MarineTraffic, National authorities, AMRO staff calculations.
Notes: Official trade statistics in local currencies are converted to U.S. dollar using monthly averages of the bilateral exchange rates. Trade statistics by mode of transport are not available for Singapore. Port congestion metrics cover data until June 27, 2021.

Figure 10. Vietnam: Port Congestion Indicators vs. Trade Statistics
(Percent, 2019=100)

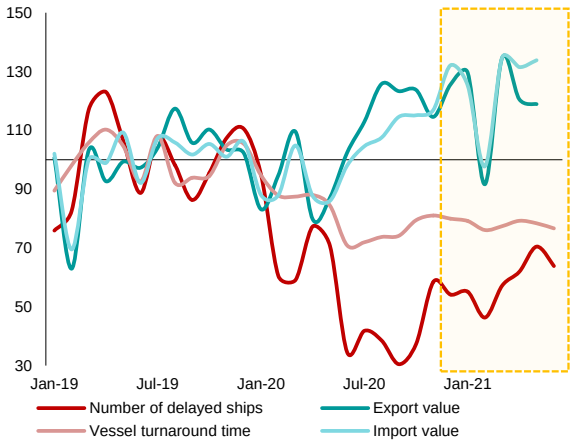
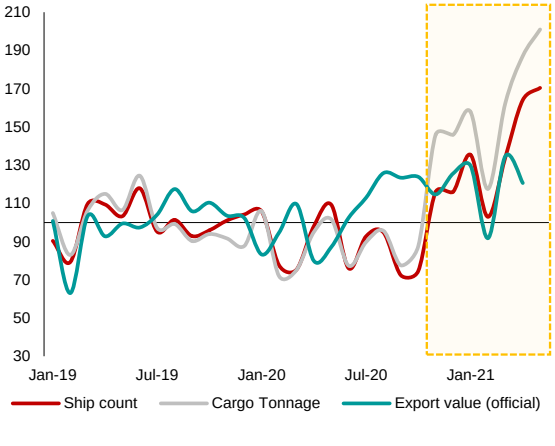


Figure 11. Vietnam: Alternative Export Indicators vs. Export Statistics
(Percent, 2019=100)



Sources: MarineTraffic, National authorities, AMRO staff calculations.
Notes: Official trade statistics in local currencies are converted to U.S. dollar using monthly averages of the VND/USD bilateral exchange rate. Port congestion and alternative export indicators cover data until June 27, 2021, and cover container ships only. Kindly refer to del Rosario and Quách (2020) for a discussion of the two AIS-based alternative indicators for exports (ship count and cargo tonnage).

13. **Economy-level regressions provide empirical evidence on how port congestion stifles exports.** Results following Simonsohn (2018) indicate a nonlinear, inverted U-shaped relationship between the port congestion metrics and trade (exports and imports) for some economies (Appendix II). For instance, the impact on Philippine exports is statistically significant, and turns negative when the number of delayed ships exceeds five percent of the 2019 average (Table 2). The same nonlinear link between vessel turnaround times and

exports could also be said of Vietnam. Elsewhere, China, Hong Kong, and Korea exhibit statistical significance with regard to the nonlinear impact of the port congestion metrics on imports. A caveat to these exercises is that causation could also go the other way, with trade influencing congestion. Further research to capture this two-way relationship could include a simultaneous equations model that controls for other determinants.

Table 2. Selected ASEAN+3: Regression Coefficients

Independent Variable (X)	$Y = c * X_{low} + d * X_{high} + e * High$		Breakpoint	U-Shaped?
	c	d		c (+) and d (-) signs
Dependent Variable (Y): Merch. Exports				
Philippines				
Vessel turnaround	0.18	-0.65	114.1	Yes
Number of delayed ships	0.91*	-0.58*	105.0	Yes#
Vietnam				
Vessel turnaround	2.03*	-0.56*	79.2	Yes#
Number of delayed ships	-0.14	-0.25*	54.5	No
Dependent Variable (Y): Merch. Imports				
China				
Vessel turnaround	1.53***	-12.42**	117.8	Yes#
Number of delayed ships	0.69***	NA	128.0	No
Hong Kong				
Vessel turnaround	2.34***	7.27**	104.9	No
Number of delayed ships	1.01***	-2.80**	105.2	Yes#
Korea				
Vessel turnaround	3.23	0.12	98.5	No
Number of delayed ships	0.88***	-1.85	110.6	Yes#

Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Notes: ***, **, * represent 1, 5, and 10 percent levels of significance, respectively. See Appendix II for the regression specifications following Simonsohn (2018). Regressions are based on data of monthly frequency.

IV. Conclusion

14. **Bottlenecks at maritime ports are disruptive to trade.** ASEAN+3 exports have rebounded sharply from the nadir in 2020, but prolonged vessel delays may also be holding back the recovery. Freight rates have soared as a result of tight shipping capacity, and could squeeze the profitability of exporters, including small to medium enterprises that are able to afford only short-term contracts for cargo shipments (Pulse News 2021).[6] If prolonged, high shipping costs could be passed through to consumer goods, compounding concerns over an acceleration in global inflation.[7] Disruptions to the shipping industry could also prompt manufacturers to shorten their supply chains over the medium term, favoring economies with

[6] The Korean government, for example, has pledged KRW 20 billion (USD 17.9 million) in special loans to small and mid-sized exporters to provide relief against the increases in shipping rates.

[7] Bulky and low-value consumer items, such as food, toys, and furniture, which tend to occupy more space in a container, are most vulnerable to higher prices. However, affected consumer items are likely to comprise a small proportion of the national consumer basket. Shipping costs also reportedly account for only a small fraction of the price of final goods, and hence may only have a marginal impact on headline inflation. But, the risks may be underestimated, given that the inflationary impact could build over time (Longley, Bosley, and Hipwell 2021).

efficient port infrastructure, among other key considerations (Longley, Bosley, and Hipwell 2021; Oxford Analytica 2021).

15. **In light of the risks and evolving backdrop to global trade, timely analyses on port congestion could aid in proactive decision-making within the region.** Greater visibility on the performance and capacity of the shipping industry and the ports they visit, as part of the region's supply chain network, can facilitate quick responses and reduce disruptions to international commerce. Prompt diagnoses of problems causing gridlocks at ports and their potential solutions could be enhanced by accelerating the digitalization of port operations. Moreover, investment in transport infrastructure, as well as technological and human capacity, could bolster port performance and will be crucial in sustaining competitiveness as the pandemic accelerates the reconfiguration of global supply chains.

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Appendix I. Port Congestion and Trade

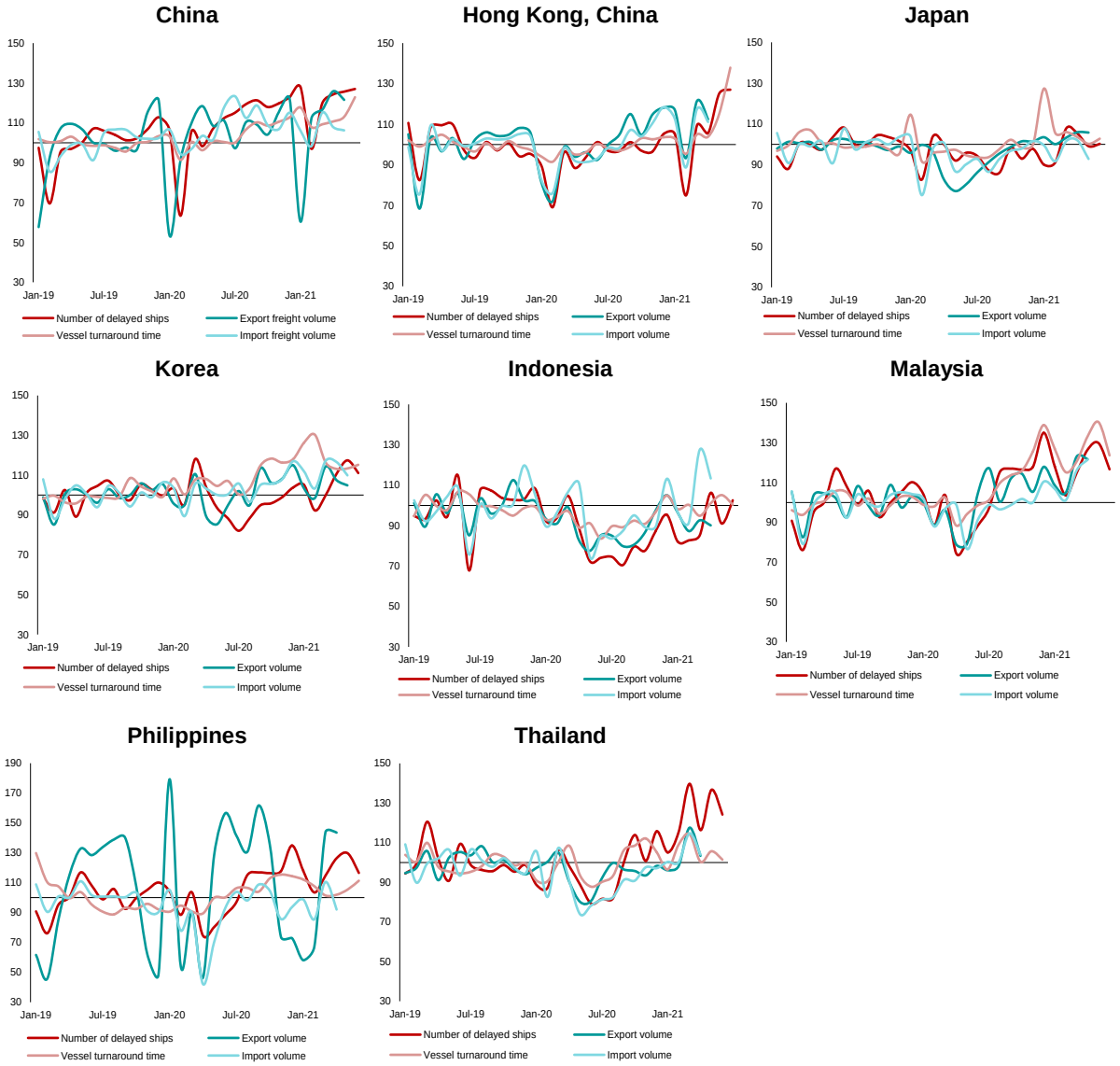
Appendix Figure 1. ASEAN+3 excluding Lao PDR: Port Congestion Metrics and Official Trade Value Statistics

(Percent, 2019=100)

Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Note: Port congestion metrics cover data until June 27, 2021. Port congestion indicators cover container ships only.

Appendix Figure 2. ASEAN+3 excluding Lao PDR: Port Congestion Metrics and Official Trade Volume Statistics

(Percent, 2019=100)



Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Note: Port congestion metrics cover data until June 27, 2021. Port congestion indicators cover container ships only.

Appendix II. Regression Methodology and Results

A. Two-Lines Test

The presence of an inverted *U*-shaped relationship between congestion and trade is examined in this note. The Simonsohn (2018) methodology is applied to test whether the effects of congestion **(X_t)** on exports or imports **(Y_t)** differ between low and high values of the former. First, a breakpoint, $\bar{X}$, in X_t is determined under a Robin Hood algorithm. Second, data for the port congestion indicator, X_t, are split at the breakpoint (hence, two lines) to conduct economy-specific linear regressions of the form:

(1) $$Y_t = cXlow_t + dXhigh_t + ehigh_t + \varepsilon_t ,$$

where,
X_t represents congestion indicators (vessel turnaround time or number of delayed ships);
Y_t represents exports or imports;
$Xlow_t = X_t - \bar{X}$, if $X_t \leq \bar{X}$ and 0 otherwise;
$Xhigh_t = X_t - \bar{X}$, if $X_t > \bar{X}$ and 0 otherwise;
$high_t = 1$, if $X_t > \bar{X}$ and 0 otherwise; and
ε_t is the error term.

Positive (+) and negative (–) signs for the coefficients c and d, respectively, indicate a nonlinear, inverted *U*-shaped relationship between the port congestion metrics and trade. If the coefficients of both c and d are significant, then the *U*-shaped relationship is also significant. However, the results are preliminary and merely indicative, given the limited number of observations with monthly data from January 2019 to May 2021 (Appendix Tables 1 and 2).

B. Quadratic Regression

Quadratic regressions are also run to check for the presence of a *U*-shaped relationship between the congestion indicators (X_t) and exports (Y_t). This method is common in the literature and is defined as follows:[8]

(2) $$Y_t = aX_t + bX_t^2 + \varepsilon_t ,$$

where ε_t is the error term for each of the 13 economies in ASEAN+3, excluding Lao PDR.

The regression estimates imply an inverted *U*-shaped function if coefficient a is a positive value, while b is negative. The function is significant if coefficient b is statistically significant. The threshold of this inverted *U* function is computed as $-a/2b$. Estimates of the coefficient b for the quadratic term X_t^2 are mostly negative and statistically significant (Appendix Table 3). However, many of the computed thresholds are beyond the range of values of the port congestion indicators.

[8] Simonsohn (2018) argues that it could be an invalid test of U-shaped relationships.

Appendix Table 1. ASEAN+3: Two-Lines Test—Exports as Dependent Variable (Equation 1)

Independent Variable (X)	Dependent Variable (Y): Merch. Exports $Y = c * X_{low} + d * X_{high} + e * High$		Breakpoint	U-Shaped? (c and d have opposite signs)
	c	d		
Brunei				
Vessel turnaround	0.62	-0.30	108.3	Yes
Number of delayed ships	-0.18	-2.33	129.6	No
Cambodia				
Vessel turnaround	0.04	-1.02	105.7	Yes
Number of delayed ships	0.08	36.91***	153.4	No
China				
Vessel turnaround	2.44***	NA	117.8	No
Number of delayed ships	1.20***	-3.52	128.0	Yes
Hong Kong				
Vessel turnaround	2.42***	10.44*	104.9	No
Number of delayed ships	1.02***	-0.02	101.2	Yes
Indonesia				
Vessel turnaround	1.48***	-0.94	97.8	Yes
Number of delayed ships	1.82***	0.01	82.1	No
Japan				
Vessel turnaround	1.85**	-0.79	103.0	Yes
Number of delayed ships	0.80***	-3.83	108.0	Yes
Korea				
Vessel turnaround	NA	NA	95.8	No
Number of delayed ships	0.68***	0.01**	117.9	No
Malaysia				
Vessel turnaround	0.74***	-1.13	134.4	Yes
Number of delayed ships	0.63***	-4.53	135.0	Yes
Myanmar				
Vessel turnaround	0.04	0.14	107.2	No
Number of delayed ships	0.07	0.08	135.3	No
Philippines				
Vessel turnaround	0.18	-0.65	114.1	Yes
Number of delayed ships	0.91*	-0.58*	105.0	Yes[#]
Singapore				
Vessel turnaround	0.46***	7.95*	127.6	No
Number of delayed ships	0.45***	17.11***	130.7	No
Thailand				
Vessel turnaround	0.35	14.17***	114.3	No
Number of delayed ships	0.31**	6.63	139.7	No
Vietnam				
Vessel turnaround	2.03*	-0.56*	79.2	Yes[#]
Number of delayed ships	-0.14	-0.25*	54.5	No

Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Notes: ***, **, * represent 1, 5, and 10 percent levels of significance, respectively. *Xlow* = $X - X_c$ if $X < X_c$, 0 otherwise; *Xhigh* = $X - X_c$, if $X > X_c$, 0 otherwise; high = 1 if $X > X_c$. Breakpoint is computed using the Robin Hood algorithm proposed by Simonsohn (2018). Regressions are based on monthly data from January 2019–May 2021.

Appendix Table 2. ASEAN+3: Two-Lines Test—Imports as Dependent Variable (Equation 1)

Independent Variable (X)	Dependent Variable (Y): Merch. Imports $Y = c * X_{low} + d * X_{high} + e * High$		Breakpoint	U-Shaped? (c and d have opposite signs)
	c	d		
Brunei				
Vessel turnaround	1.56	-1.86	97.1	Yes
Number of delayed ships	0.39	-1.08	133.3	Yes
Cambodia				
Vessel turnaround	0.18	0.06	103.9	No
Number of delayed ships	0.08	-0.45	113.0	Yes
China				
Vessel turnaround	1.53***	-12.42**	117.8	Yes[#]
Number of delayed ships	0.69***	NA	128.0	No
Hong Kong				
Vessel turnaround	2.34***	7.27**	104.9	No
Number of delayed ships	1.01***	-2.80**	105.2	Yes[#]
Indonesia				
Vessel turnaround	2.39**	-1.23	97.7	Yes
Number of delayed ships	0.96***	-0.01	102.5	Yes
Japan				
Vessel turnaround	1.69**	-0.08	102.3	Yes
Number of delayed ships	0.90***	5.49	108.0	No
Korea				
Vessel turnaround	3.23	0.12	98.5	No
Number of delayed ships	0.88***	-1.85	110.6	Yes[#]
Malaysia				
Vessel turnaround	0.32	NA	138.9	Yes
Number of delayed ships	0.39**	-5.11	135.0	Yes
Myanmar				
Vessel turnaround	-0.16	0.52	102.7	Yes
Number of delayed ships	0.31***	-15.43	173.5	Yes
Philippines				
Vessel turnaround	-0.01	1.15***	114.6	Yes
Number of delayed ships	0.89	-0.65*	106.9	Yes
Singapore				
Vessel turnaround	0.35**	9.75**	127.6	No
Number of delayed ships	0.41***	11.93***	130.7	No
Thailand				
Vessel turnaround	0.64*	13.49***	114.3	No
Number of delayed ships	0.45***	3.8	139.7	No
Vietnam				
Vessel turnaround	4.30***	-0.57	78.8	Yes
Number of delayed ships	0.97**	-0.1	57.4	Yes

Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Notes: ***, **, * represent 1, 5, and 10 percent levels of significance, respectively. *Xlow* = $X - X_c$ if $X < X_c$, 0 otherwise; *Xhigh* = $X - X_c$, if $X > X_c$, 0 otherwise; high = 1 if $X > X_c$. Breakpoint is computed using the Robin Hood algorithm proposed by Simonsohn (2018). Regressions are based on monthly data from January 2019–May 2021.

Appendix Table 3. ASEAN+3: Coefficients from Quadratic Regressions (Equation 2)

Independent Variable (X)	Dependent Variable (Y): Merch. Exports ($Y = a*X + b*X^2$)		Computed Threshold (-a/2b)	Mean
	a	b		
China				
Vessel turnaround time	-0.17	0.010***	NA	103.5
Number of delayed ships	0.76***	0.000*	NA	107.0
Hong Kong, China				
Vessel turnaround time	-0.37	0.010**	NA	100.0
Number of delayed ships	1.24***	-0.002	307.2	98.3
Japan				
Vessel turnaround time	1.60***	-0.006**	126.6	100.6
Number of delayed ships	1.16***	-0.002	340.4	97.3
Korea				
Vessel turnaround time	1.75***	-0.008***	108.4	107.2
Number of delayed ships	1.36***	-0.004	166.6	97.3
Indonesia				
Vessel turnaround time	1.41***	-0.004	192.3	96.9
Number of delayed ships	1.90***	-0.008***	112.3	91.7
Malaysia				
Vessel turnaround time	1.18***	-0.002	260.5	107.7
Number of delayed ships	1.33***	-0.003**	190.4	104.5
Philippines				
Vessel turnaround time	1.81***	-0.008***	107.6	101.9
Number of delayed ships	1.73***	-0.008***	114.7	103.5
Singapore				
Vessel turnaround time	1.41***	-0.004***	163.2	106.9
Number of delayed ships	1.50***	-0.005***	148.9	103.6
Thailand				
Vessel turnaround time	1.61***	-0.006***	127.5	100.4
Number of delayed ships	1.56***	-0.006***	135.0	101.9
Brunei Darussalam				
Vessel turnaround time	1.92***	-0.009***	103.1	96.6
Number of delayed ships	1.85***	-0.008***	112.5	101.5
Cambodia				
Vessel turnaround time	1.75***	-0.008***	108.4	80.8
Number of delayed ships	1.36***	-0.004	166.6	65.3
Myanmar				
Vessel turnaround time	1.91***	-0.009***	104.4	89.7
Number of delayed ships	1.74***	-0.007***	120.0	97.0
Vietnam				
Vessel turnaround time	2.99***	-0.020***	75.1	88.4
Number of delayed ships	3.17***	-0.021***	75.0	74.1

Source: MarineTraffic, national authorities via Haver Analytics, AMRO staff calculations.
Note: ***, **, * represent 1, 5, and 10 percent levels of significance, respectively. Regressions are based on monthly data from January 2019–May 2021.

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