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East Asian Production Networks Amidst the COVID-19 Shock*

Ayako OBASHI†

Aoyama Gakuin University, Japan

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Abstract: *In the East Asian context, previous studies showed that trade occurring through production networks remained relatively steady amidst an economic shock and recovered faster and stronger once the shock was over. Using finely disaggregated product-level monthly bilateral trade data, we examine whether network trade in the East Asian region has been robust and resilient in face of the COVID-19 crisis, as well as in normal times, by conducting a series of survival analyses. We find a new set of empirical evidence suggesting the robustness of East Asian network trade in normal times and its resilience even amidst the COVID-19 shock.*

Keywords: East Asian production networks; COVID-19; Survival analysis

JEL Classification: F14; F23

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† Corresponding author. Ayako Obashi, address: School of International Politics, Economics and Communication, Aoyama Gakuin University, 4-4-25 Shibuya, Shibuya-ku, Tokyo 150-8366, Japan. Phone: 81-3-3709-9809. E-mail: obashi@aoyamagakuin.jp

1. Introduction

The worldwide COVID-19 outbreak has impacted internationalised production and trade. The more deeply countries are interconnected through international economic activities, the more likely an economic shock originating in one country is to be transmitted to another. Internationalised production chains have been blamed for working as a transmission mechanism in the spread of shocks, reflected in widespread decreases in international trade. The shock transmission through international production chains has triggered a renewed argument that shorter supply chains and the reshoring of production sites back to the domestic economy would reduce vulnerability to economic shocks (Miroudot, 2020).

Given the need for coordination between upstream and downstream production stages, as well as the presence of the sunk costs of investing in newly fragmented production blocks, however, the network-forming firms would put importance not only on lowering production costs but also on the stability of trade relationships. Due to this relation-specific nature of transactions, unlike goods sold on the open market, trade relationships for intermediate goods within production networks might be rather resistant to a shock.

With this line of argument in mind, previous studies showed that East Asian trade occurring through production networks remained relatively steady amidst a demand or supply shock and recovered faster and stronger once the shock was over (Obashi, 2010; Ando and Kimura, 2012; Okubo, Kimura, and Teshima, 2014). Despite the concerned shock transmission mechanism, the network trade in East Asia was rather robust and resilient to previous shocks. Are similar robustness and resilience of the regional network trade found in the face of the latest COVID-19 shock?

Unlike previous crises, COVID-19 generated both supply and demand shocks (Baldwin, 2020). ASEAN Member States (AMS) and other neighbouring countries in East Asia were first hit by the COVID-19 crisis as a supply shock or disrupted imports from China in January and February 2020. Then, social-distancing policies halted supply and dampened demand. Nevertheless, production in China has almost resumed and the East Asian network trade centring on China is also (expected to be) recovering. Still, low demand will hurt production facilities and networks if it

persists in the long term (Kimura, 2020). It is time to sort out the observed facts and evidence from the latest monthly trade data for or against these kinds of arguments.

In this paper, we investigate the robustness and resilience of East Asian network trade amidst the COVID-19 shock. To do so, making use of finely disaggregated product-level monthly bilateral trade data obtained from UN Comtrade, we conduct a series of survival analyses, in line with Besedeš and Prusa (2006a, 2006b) and Obashi (2011). In particular, Obashi (2011) provided evidence suggesting that transactions of intermediate goods within production networks in East Asia were not only highly robust in normal times but also resilient amidst the Asian crisis in 1997–1998. We apply a similar set of analyses to the case of the COVID-19 shock and its effects on monthly trade.

Specifically, we regard a trade relationship as being robust if the transactions tended not to be disrupted and continued to be active over time. Even when a trade relationship was discontinued for whatever reason, we regard it as being resilient if the transaction was restored after an acceptable period of disruption. Conducting survival analyses enables us to answer the following questions: Was the probability of continued trading relatively higher in East Asian network trade (i.e. robustness), compared to the corresponding trade outside East Asia, at normal times and even amidst the COVID-19 shock? Was the probability of recovering from disrupted trading relatively higher in East Asian network trade (i.e. resilience)?

We find evidence suggesting the robustness of East Asian network trade in normal times, in the sense that transactions within East Asian production networks are less likely to be disrupted to a statistically significant degree, compared to those within networks outside the region, after controlling for possible covariates. In the period under the COVID-19 shock, however, East Asian network trade relationships do not appear to live longer to a statistically significant degree. Despite the robustness of East Asian network trade in normal times, transactions within East Asian production networks were disrupted amidst the COVID-19 shock at a rate comparable to the level of extra-regional network trade.

We also find evidence suggesting the resilience of East Asian network trade even amidst the COVID-19 shock as well as in normal times, in the sense that once-disrupted transactions within East Asian production networks are more likely to be

restored to a statistically significant degree, compared to extra-regional network trade, after controlling for possible covariates. Although the disrupted transactions within East Asian production networks in the face of the COVID-19 crisis appear to have not yet recovered at a rate as high as normal, at least as of June 2020, we find that East Asian network trade remains more resilient than extra-regional network trade, even amidst the COVID-19 shock.

The remainder of this paper is organised as follows. Section 2 describes how we constructed a panel data set of finely disaggregated product-level monthly bilateral trade data. Using the monthly trade data set, section 3 overviews the ins and outs of product-level bilateral trade relationships over time. Given the observed facts on the ins and outs of trade relationships, section 4 conducts a series of survival analyses to investigate the robustness and resilience of East Asian network trade. Section 5 concludes.

2. Data Description

To examine whether East Asian network trade has been robust and resilient amidst the COVID-19 crisis, we use up-to-date bilateral merchandise trade data at the Harmonized System (HS) six-digit product level, from January 2016 to June 2020 on a monthly basis, obtained from UN Comtrade (as of 24 September 2020). Monthly export and import statistics are reported by 29 countries and regions, as listed in Appendix Table A1, continuously from January 2016 to June 2020.[1] There are a few cases in which a country did not report trade statistics at all for a single month, though the statistics for adjacent months are available. We filled those missing gaps in the trade statistics by taking a simple average over the two adjacent months so that we could include as many continued reporter countries throughout the sample period as possible.

[1] Although monthly trade statistics reported by the European Union (EU)-28 (as a whole) are also available from UN Comtrade, we focus on examining the trade flows of individual member states as independent statistical units in this study. As of 24 September 2020, the latest data for July 2020 were available but were reported by 17 countries and regions only. We thus decided to focus on examining the monthly trade data up to June 2020. We downloaded all the monthly trade data available as of 6 October 2020 from UN Comtrade.

We organised and cleaned the raw monthly trade data in the following four steps. First, combining import statistics reported by 29 countries with their export statistics using a conventional cost insurance and freight (CIF)/free on board (FOB) ratio of 1.1, we created a panel data set of monthly bilateral trade at the HS six-digit level.

Second, we converted the HS six-digit product codes to Standard International Trade Classification (SITC) Rev. 4 codes at the most disaggregated level (i.e. four- or five-digit codes, which are usually called leaf codes).[2] All 29 countries reported trade statistics based on the HS 2012 version at the beginning of the sample period (i.e. January 2016), except for the Philippines. Countries other than the Philippines appear to have started using a newer HS 2017 version at some point of time during the sample period; however, we cannot identify which HS version each monthly trade data is based on. Given such a data constraint issue, for countries other than the Philippines, we first used the latest conversion table from the HS 2017 to SITC Rev. 4 and then used the conversion table from HS 2012 to SITC Rev. 4 for the unmatched HS codes that are not included in the HS 2017 version (but in the HS 2012 version). The Philippines used the HS 2002 version in 2016 and started using HS 2012 from some month in 2017. For the Philippines, because there is no conversion table from HS 2002 to SITC Rev. 4 available, we instead made use of a correlation table between HS 2002 and SITC Rev. 4. Although the correlation table includes one-to-many correspondences (i.e. one HS code is converted to multiple SITC codes), we simply selected the first-listed SITC Rev. 4 codes in such cases.[3]

Third, we connected the converted SITC Rev. 4 codes with the RIETI Trade Industry Database (RIETI–TID) production stage indicator, which is available based on SITC Rev. 4. By doing so, we identified the (most applicable) production stages for the respective HS six-digit codes. The RIETI–TID provides the list of

[2] Monthly trade statistics available from UN Comtrade are all reported based on some version of the HS classification (though without information on the exact version used). We thus need to use conversion tables from HS codes to SITC Rev. 4 codes so that we can make use of the production stage indicator described below. Conversion (and correlation) tables are available at the UNSD webpage:
https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

[3] One-to-many correspondence cases account for less than 9% of the Philippines' reported data.

SITC Rev. 4 codes with their production stage indicator values.[4] The production stage indicator takes an integer value from 1 to 5, corresponding to five (sub)categories based on the stages of the production process: primary goods (indicator = 1); intermediate goods, which include (semi-)processed materials (= 2) and manufactured parts and components (= 3) as subcategories; and final goods, which include capital goods (= 4) and consumption goods (= 5) as subcategories.

Finally, we cleaned up the data set by dropping observations on special or miscellaneous categories of trading partner counties and regions. We also omitted observations for HS six-digit codes with no corresponding production stage indicator.[5] We ultimately obtained a panel data set of monthly bilateral trade at the HS six-digit level from January 2016 to June 2020. The data set includes 11,325 exporter-importer country pairs[6] that had some merchandise transactions during the sample period, covering 5,999 HS six-digit codes for either the HS 2002, 2012, or 2017 version, which correspond to 2,978 SITC Rev. 4 codes, with the production stage information.[7]

To highlight the robustness and resilience of East Asian network trade, we are interested in comparing the trade flows of i) non-manufactured goods, which include primary goods, processed materials, and consumption goods, according to the RIETI-TID production stage indicator; ii) manufactured goods except machinery, which include processed materials and consumption goods; and iii) machinery goods, which include manufactured parts and components, capital goods, and consumption goods.[8] In the HS classification, manufactured goods span from the HS28 to the HS92 two-digit chapter, amongst which the HS84–HS92 chapters

[4] See http://www.rieti-tid.com/.
[5] The following four SITC Rev. 4 codes are not included in the RIETI–TID production stage indicator list: electric current (3510); postal packages not classified according to kind (9110); special transactions and commodities not classified according to kind (9310); coins (other than gold coins), not being legal tender (9610).
[6] In total, 234 countries and regions are included in the data set as a single statistical unit of exporter or importer or both.
[7] There are 5,385 six-digit codes in the HS 2017 version of the classification (except a miscellaneous code of 999999), 5,205 codes in the HS 2012 version, and 5,222 codes in the HS 2002 version. In our data set, there are 5,999 distinct HS codes, which suggests that about one-tenth of HS codes are inconsistent between the three different versions of HS classification. In a future revision, we will consider the possible overestimation of the ins and outs of trade relationships due to the changes in the HS version employed by a country as a robustness check.
[8] Although there exist few HS six-digit codes classified under the production-stage categories other than those listed above, we omit those negligible observations from our analysis.

are machinery goods. The remaining chapters are regarded as non-manufactured goods. As 'network trade', we focus particularly on examining trade in manufactured parts and components (which account for a part of machinery goods), but under a broader definition, we also consider trade in capital goods (which account for another part of machinery goods) as well as machinery consumption goods.

For 'East Asian trade', we here define East Asia functionally as economies that are taking part in regional economic dynamism or region-wide international production networks. Namely, East Asian trade in our definition is engaged by AMS, China, Japan, the Republic of Korea (hereafter Korea), Australia, New Zealand, or India on either the exporter or importer side.

3. Observed Facts on the Ins and Outs of Monthly Bilateral Trade

Using the HS six-digit-level monthly bilateral trade data set constructed as described above, this section provides observed facts on the ins and outs of product-level bilateral trade relationships.

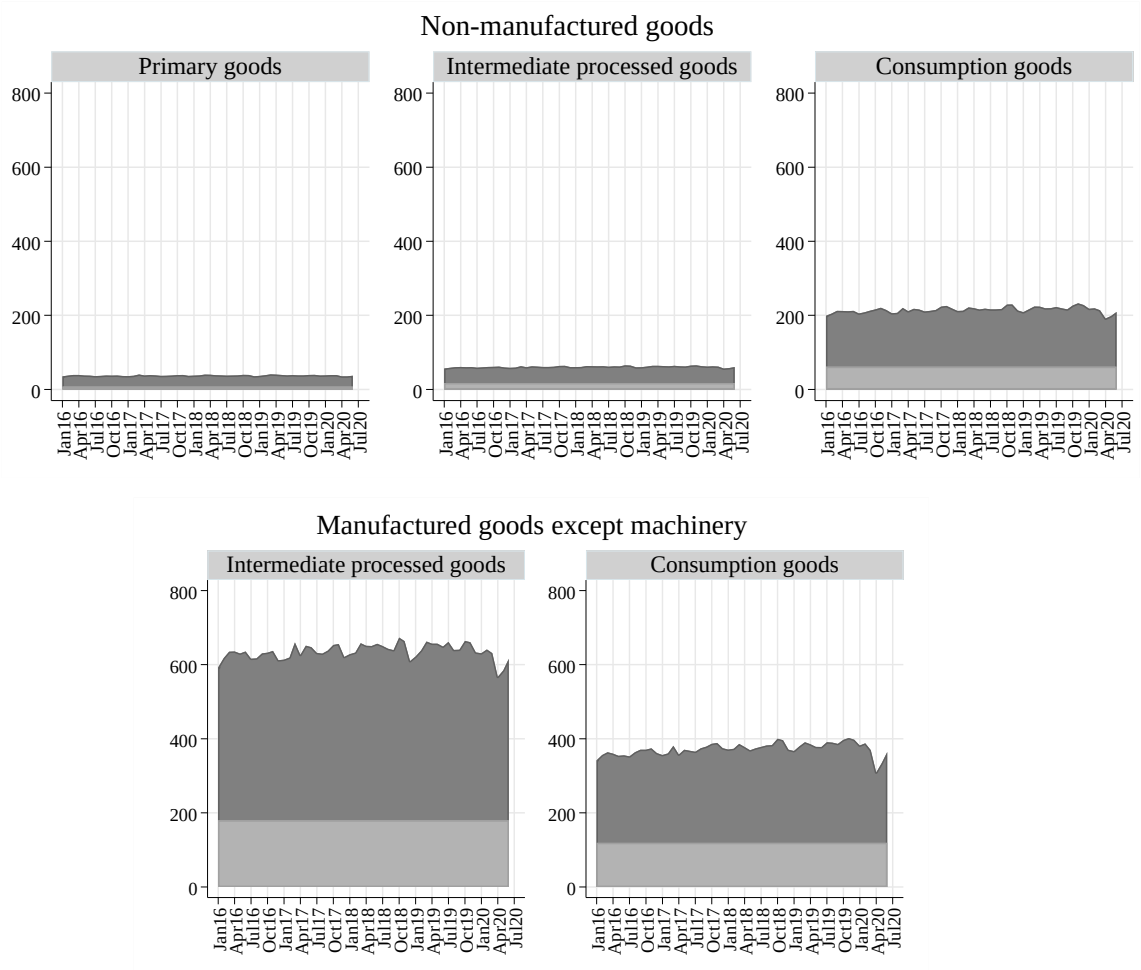
3.1. Changes in the number of trade relationships

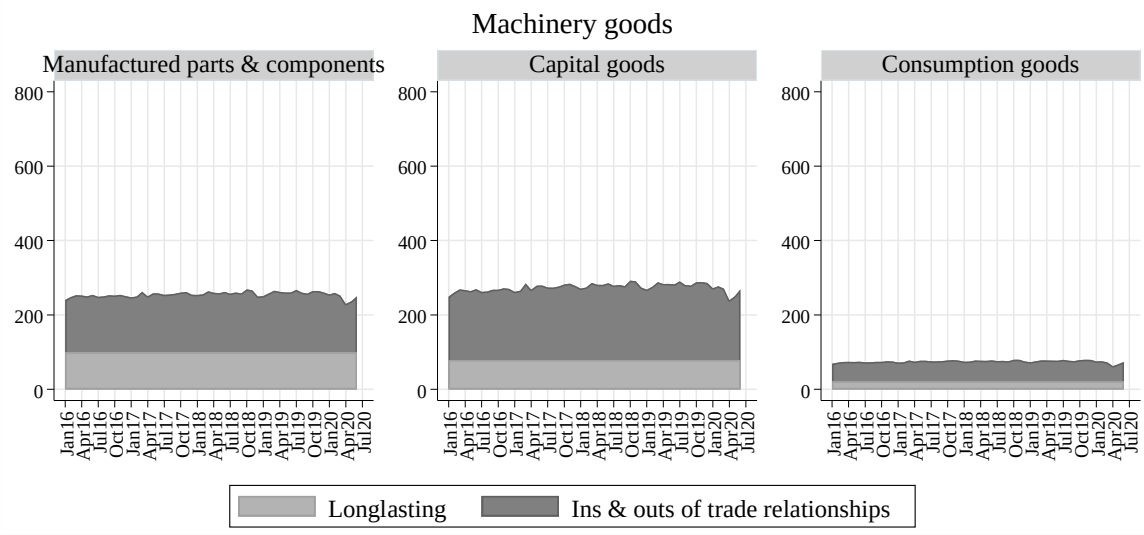
Let us define a trade relationship by a combination of the exporter country, importer country, and HS six-digit code. We begin by sorting out the observed changes in the number of trade relationships (i.e. exporter-importer-product pairs) by sector and production-stage category. We place special interest in the trade in manufactured parts and components that we think represents network trade.

Area charts in Figure 1 show the over-time changes in the number of trade relationships for non-manufactured goods, manufactured goods except machinery, and machinery goods, by production-stage category. The height of each area chart indicates the number of trade relationships at each point in time, from January 2016 to June 2020. Each area chart is divided into two portions, the lighter-coloured one which indicates the number of long-lasting trade relationships that continued to be active in transactions throughout the sample period. The rest, the dark-coloured portions, corresponds to the ins and outs of the trade relationships; that is, they

started to be traded and appeared in the data set (i.e. ins) or were disrupted and disappeared from the data set (i.e. outs) at some point during the sample period. Table 1 complements Figure 1 by showing the proportion of long-lasting trade relationships, averaged over the period of interest, by sector and production-stage category.

Figure 1. Changes in the Number of Trade Relationships, by Sector and Production-stage Category ('000)





Notes: The light-coloured area represents the number of long-lasting trade relationships that continued to be active throughout the sample period. The dark-coloured area represents the ins and outs, indicating the number of trade relationships that started or were disrupted at some point during the period.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Table 1. Proportion of Long-lasting Trade Relationships, by Sector and Production-stage Category (%)

	Worldwide trade		East Asian trade	
Period	Normal	COVID	Normal	COVID
Overall	29.1	30.4	28.9	30.3
Non-manufactured goods				
Primary goods	20.4	20.8	18.5	19.5
Intermediate processed goods	28.1	28.8	25.8	26.8
Consumption goods	28.4	29.6	25.5	26.8
Manufactured goods except machinery				
Intermediate processed goods	28.2	29.5	27.3	28.7
Consumption goods	31.8	33.5	32.4	34.0
Machinery goods				
Manufactured parts & components	38.8	40.4	41.4	43.0
Capital goods	28.5	29.9	30.8	32.5
Consumption goods	28.4	30.4	29.4	31.5

Notes: Long-lasting trade relationships are those that continued to be active throughout the period of interest. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Overall, long-lasting trade relationships do not make up the majority of international transactions in terms of numbers. The proportion of long-lasting ones in the total number of trade relationships is on average 29.1% monthly in normal times, from January 2016 to December 2019, and 30.4% amidst the COVID-19 shock, from January 2020 to June 2020 (see the two left-hand columns in Table 1). It is noteworthy that the proportion of long-lasting relationships is strikingly high for manufactured parts and components, reaching 38.8% in normal times and 40.4% amidst the COVID-19 shock (see the area chart in the lower-left corner of Figure 1).

Even for manufactured parts and components, the number of trade relationships declined greatly amidst the COVID-19 shock. In each area chart, there is a noticeable V-shaped decline with the lowest figure recorded in April 2020. It appears that a greater number of trade relationships were disrupted due to the COVID-19 shock, especially in April 2020, compared to the previous, normal times. Meanwhile, however, Figure 1 clearly indicates a sign of the recovery of disrupted trade relationships, as of June 2020.

Appendix Figure A1 complements Figure 1 by focusing on examining East Asian trade relationships only. The overall trend in the over-time changes in the number of trade relationships is like what we observed in Figure 1 above. The monthly average proportion of long-lasting trade relationships in East Asia is 28.9% in normal times and 30.3% amidst the COVID-19 shock (see the two right-hand columns in Table 1), which are comparable to the worldwide figures. The high proportion of long-lasting relationships observed for manufactured parts and components, however, is especially outstanding in East Asian trade: the proportion reaches 41.4% in normal times and 43.0% amidst the COVID-19 shock.

The ins and outs of trade relationships would occur simultaneously every month to a greater degree than what is simply observed in the net changes in the number of trade relationships. Still, the relatively high proportion of long-lasting trade relationships of manufactured parts and components especially in East Asia can be interpreted as suggesting higher stability in East Asian network trade.

3.2. Ins and outs of trade relationships in normal times

Next, focusing on normal times, from January 2016 to December 2019, we overview the ins and outs of trade relationships by sector and production-stage category. In doing so, we place a special emphasis on East Asian network trade. Tables 2, 3, and 4 show the basic statistics on the ins and outs of trade relationships from different aspects. All the statistics are calculated based on the data for the trade relationships defined at the exporter-importer-product level that had some transaction observed during the period of interest. In other words, we ignore zero-valued trade relationships in our data analyses below.

Table 2 shows the basic statistics on the counted number of months in which a trade relationship was active in transactions during the period. The statistics are summarised by sector and production-stage category, accompanied by the overall figures for East Asian and other trade relationships for comparative purposes. Looking at the figures for the trade relationships of non-manufactured goods, the central tendency of the number of months active is uniformly lower in East Asian trade compared to other trade. In contrast, the central tendency figures for trade relationships of manufactured goods are higher in East Asian trade than in other trade. In particular, the mean and other central tendency figures for machinery goods, especially manufactured parts and components, are saliently higher in East Asian trade.

Table 2. Number of Months Active, from January 2016 to December 2019, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships

East Asian trade relationships

	Mean	Percentiles					Number of trade relationships
		10	25	Median	75	90	
Overall	15.9	1	2	7	29	48	1,371,830
Non-manufactured goods							
Primary goods	12.0	1	1	4	18	42	29,715
Intermediate processed goods	14.9	1	2	6	26	47	41,333
Consumption goods	14.7	1	2	6	25	47	137,722
Manufactured goods except machinery							
Intermediate processed goods	15.0	1	2	6	27	47	477,302
Consumption goods	16.6	1	2	7	32	48	244,502
Machinery goods							
Manufactured parts & components	19.9	1	2	11	43	48	162,176
Capital goods	15.3	1	2	6	28	48	221,986
Consumption goods	15.3	1	2	6	28	48	57,094

Other trade relationships

	Mean	Percentiles					Number of trade relationships
		10	25	Median	75	90	
Overall	15.3	1	2	6	28	48	4,675,689
Non-manufactured goods							
Primary goods	12.8	1	1	5	20	43	114,141
Intermediate processed goods	15.5	1	2	6	28	48	150,977
Consumption goods	16.0	1	2	7	30	48	521,858
Manufactured goods except machinery							
Intermediate processed goods	14.9	1	1	6	26	47	1,576,225
Consumption goods	16.4	1	2	7	32	48	851,451
Machinery goods							
Manufactured parts & components	17.2	1	2	7	36	48	526,813
Capital goods	13.3	1	1	4	21	46	743,091
Consumption goods	14.5	1	1	5	25	47	191,133

Notes: The maximum possible number of months active is 48. ‘East Asia’ is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

On top of the fact that East Asian network trade is outstanding in terms of the number of months active in transactions, Table 3 suggests that the activeness of the trade relationships in East Asian network trade is (at least partially) attributable to the longer duration of trade once a trade relationship is established. Table 3 shows the basic statistics on the length of time (months) a certain trade relationship continued to be active in transactions once the transaction was launched. Specifically, we identified a 'spell' for which a transaction of a certain product between certain exporter and importer countries lasted for some period. The spell(s) is defined at the exporter-importer-product level. There would be multiple spells for each 'trade relationship', which is an exporter-importer-product pair. We calculated the basic statistics for the length of the spells.

Table 3. Length of Spells, from January 2016 to December 2019, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships

East Asian trade relationships

		Percentiles					Number of
	Mean	10	25	Median	75	90	observations
Overall	3.8	1	1	1	2	6	5,666,767
Non-manufactured goods							
Primary goods	3.0	1	1	1	2	5	119,961
Intermediate processed goods	3.5	1	1	1	2	6	177,619
Consumption goods	3.5	1	1	1	2	6	571,964
Manufactured goods except machinery							
Intermediate processed goods	3.6	1	1	1	2	6	1,984,860
Consumption goods	4.0	1	1	1	3	7	1,007,449
Machinery goods							
Manufactured parts & components	4.8	1	1	1	3	9	667,204
Capital goods	3.7	1	1	1	2	6	911,879
Consumption goods	3.9	1	1	1	2	7	225,831

Other trade relationships

	Mean	Percentiles					Number of observations
		10	25	Median	75	90	
Overall	3.9	1	1	1	2	6	18,470,378
Non-manufactured goods							
Primary goods	3.3	1	1	1	2	6	448,248
Intermediate processed goods	3.8	1	1	1	2	7	608,087
Consumption goods	4.1	1	1	1	3	7	2,020,334
Manufactured goods except machinery							
Intermediate processed goods	3.7	1	1	1	2	6	6,298,159
Consumption goods	4.2	1	1	1	3	7	3,334,743
Machinery goods							
Manufactured parts & components	4.3	1	1	1	2	7	2,107,691
Capital goods	3.4	1	1	1	2	5	2,918,554
Consumption goods	3.8	1	1	1	2	6	734,562

Notes: The maximum possible length of spell is 48 (months). 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Comparing the mean values reported in Table 3 between East Asian and other trade, the overall mean spell length is 3.8 months in East Asian trade, which is slightly shorter than 3.9 months calculated for other trade. A similar tendency of a shorter length of spell in East Asian trade is observed for non-manufactured goods and for manufactured goods except machinery. A contrasting tendency, however, is observed for machinery goods, especially, manufactured parts and components: the mean spell length is 4.8 months in East Asian trade, which is higher than 4.3 months for other trade. Furthermore, in East Asian trade of manufactured parts and components, more than one-tenth of trade relationships last for 9 months or more.

Meanwhile, the median length of the spells is 1 month for all product categories for both East Asian and other trade, including East Asian trade of manufactured parts and components. About half of trade relationships last only for a single month, disappearing in the next month after the transaction was launched. Given such a high frequency of short-length spells, it is notable that some trade relationships of East Asian network trade are relatively longer-lived.

The observed high frequency of short-lived spells may be accompanied by frequent ins and outs in trade relationships. To put it differently, some may wonder if the relatively longer-lived East Asian network trade relationships are attributable

to the less-frequent disruptions of transactions. In this regard, Table 4 shows the basic statistics on the frequency of multiple spells at the exporter-importer-product level by checking how many times a certain trade relationship was disrupted but restored. Looking at the mean number of spells, East Asian trade relationships for manufactured parts and components on average had 4.1 spells (or disruptions followed by recoveries), which is slightly more frequent than the 4.0 spells that other trade relationships experienced. This would suggest that the longer duration of East Asian network trade relationships is not accounted for by less-frequent disruptions and recoveries.

Table 4. Number of Spells at the Exporter-Importer-Product level, from January 2016 to December 2019, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships

East Asian trade relationships

		Percentiles						Number of trade
	Mean	10	25	Median	75	90	Maximum	relationships
Overall	4.1	1	1	3	6	10	23	1,371,830
Non-manufactured goods								
Primary goods	4.0	1	1	2	6	10	21	29,715
Intermediate processed goods	4.3	1	1	3	7	10	20	41,333
Consumption goods	4.2	1	1	3	6	10	21	137,722
Manufactured goods except machinery								
Intermediate processed goods	4.2	1	1	3	6	10	23	477,302
Consumption goods	4.1	1	1	3	6	10	20	244,502
Machinery goods								
Manufactured parts & components	4.1	1	1	2	7	10	22	162,176
Capital goods	4.1	1	1	2	6	10	20	221,986
Consumption goods	4.0	1	1	2	6	10	19	57,094

Other trade relationships

	Mean	Percentiles					Maximum	Number of trade relationships
		10	25	Median	75	90		
Overall	4.0	1	1	2	6	10	22	4,675,689
Non-manufactured goods								
Primary goods	3.9	1	1	2	6	10	21	114,141
Intermediate processed goods	4.0	1	1	2	6	10	21	150,977
Consumption goods	3.9	1	1	2	6	9	22	521,858
Manufactured goods except machinery								
Intermediate processed goods	4.0	1	1	2	6	10	21	1,576,225
Consumption goods	3.9	1	1	2	6	9	22	851,451
Machinery goods								
Manufactured parts & components	4.0	1	1	2	6	10	22	526,813
Capital goods	3.9	1	1	2	6	10	21	743,091
Consumption goods	3.8	1	1	2	6	10	20	191,133

Notes: The maximum possible number of spells is 24. 'East Asia' is defined as 16 economies, comprising AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

In addition, at least during the period of interest, the average lengths are quite comparable amongst product categories as well as between East Asian and other trade, even though East Asian network trade relationships are outstanding in terms of the number of months active in transactions (Table 2) and in terms of the length of the spells (Table 3). East Asian network trade relationships are not an exception and tend to experience frequent ins and outs, on average, once a year. Nevertheless, East Asian network trade relationships appear to be longer-lived once a transaction is established, which we look further into in the next section by conducting a series of survival analyses.

4. Survival Analysis

Given the facts on the ins and outs of product-level bilateral trade relationships overviewed in the previous section, we investigate the robustness and resilience of East Asian network trade by conducting a series of survival analyses.

4.1. Probability of continued trading

We first analyse the probability of continued trading once a transaction at the exporter-importer-product level (i.e. spell) is launched. We are interested in confirming that East Asian network trade relationships live longer to a statistically significant degree compared to the trade relationships outside East Asia once a transaction is established. To do so, we conduct the Kaplan-Meier estimation of survival rates along the lines of Besedeš and Prusa (2006a) and other subsequent studies. We estimate the survival function nonparametrically using the Kaplan-Meier product limit estimator. The survival function of T, the time to failure event, is given by

$$S(t) = Pr(T > t).$$

$S(t)$ equals one at $t = 0$ and decreases towards zero as t increases. The failure event in our study is a disruption in transactions at the exporter-importer-product level; that is, a termination of the spell of a certain trade relationship.

Table 5 shows the estimated Kaplan-Meier survival rates for East Asian trade relationships compared to other trade relationships, by sector and product-stage category. The survival rates are estimated using the data set of spells that existed in January 2016 or later up to December 2019, focusing on the normal times before the COVID-19 shock. We treat multiple spells of a certain trade relationship as independent from each other because different spells would include different sets of trading firms even for the same combination of exporter-importer-country pairs and products. The first six columns of the table summarise the survival rates at the 1st, 2nd, 4th, 8th, 16th, and 32nd month since a spell, or transaction, was launched. Spells existing in the end month of the normal period, December 2019, are classified as right-censored rather than as 'failures' (i.e. termination). It is appropriate to interpret the length of right-censored spells as the lower bound. This accounts for the difference between the number of all spells and the number of disrupted spells, both of which are reported in the middle set of columns of the table.[9]

[9] In Table 5 and the associated Figure 2, we made no modification to deal with the left-censoring issue of the data set. That is, we treated spells that existed in the first month of the normal period, January 2016, as having started from January 2016, even though they may have started earlier.

Table 5. Estimated Kaplan-Meier Survival Rates, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships in the Normal Period, January 2016–December 2019

	Time since a transaction was launched						Number of observations		Log-rank test
	1st month	2nd month	4th month	8th month	16th month	32nd month	All spells	Disrupted spells	Pr>chi2
Non-manufactured goods									
Primary goods									
East Asian trade	0.38	0.23	0.13	0.07	0.04	0.03	119,961	112,564	0.0000
Other trade	0.40	0.25	0.14	0.08	0.05	0.03	448,248	418,001	
Intermediate processed goods									
East Asian trade	0.40	0.25	0.14	0.08	0.06	0.04	177,619	164,776	0.0000
Other trade	0.42	0.26	0.16	0.10	0.07	0.05	608,087	558,154	
Consumption goods									
East Asian trade	0.41	0.26	0.15	0.09	0.06	0.04	571,964	527,587	0.0000
Other trade	0.44	0.29	0.18	0.11	0.07	0.06	2,020,334	1,836,859	
Manufactured goods except machinery									
Intermediate processed goods									
East Asian trade	0.41	0.25	0.15	0.09	0.06	0.04	1,984,860	1,835,140	0.0000
Other trade	0.41	0.26	0.15	0.09	0.06	0.05	6,298,159	5,814,811	
Consumption goods									
East Asian trade	0.43	0.27	0.16	0.10	0.07	0.06	1,007,449	918,051	0.0000
Other trade	0.43	0.28	0.17	0.11	0.07	0.06	3,334,743	3,026,665	
Machinery goods									
Manufactured parts & components									
East Asian trade	0.45	0.29	0.18	0.12	0.09	0.07	667,204	598,748	0.0000
Other trade	0.42	0.27	0.16	0.11	0.08	0.06	2,107,691	1,915,744	
Capital goods									
East Asian trade	0.41	0.25	0.15	0.09	0.06	0.05	911,879	839,174	0.0000
Other trade	0.38	0.23	0.13	0.08	0.05	0.04	2,918,554	2,705,153	
Consumption goods									
East Asian trade	0.41	0.26	0.15	0.10	0.07	0.05	225,831	207,106	0.0000
Other trade	0.40	0.25	0.15	0.09	0.07	0.05	734,562	673,982	

Notes: The survival rate here is the probability of continued trading once a transaction (i.e. spell) is launched. The p-value in the rightmost column indicates whether the survival function for East Asian trade is statistically different than that for other trade. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Overall, the survival rates in the first month range from 38% to 45%, and the rates further decline to 13% to 18% in the fourth month. A substantial portion of transactions were terminated within 4 months after the transaction was launched, especially within the first month. In the later months, the survival rates tend to

remain almost constant. Once a transaction continues to be active for 16 months or more, it is highly likely to last long.

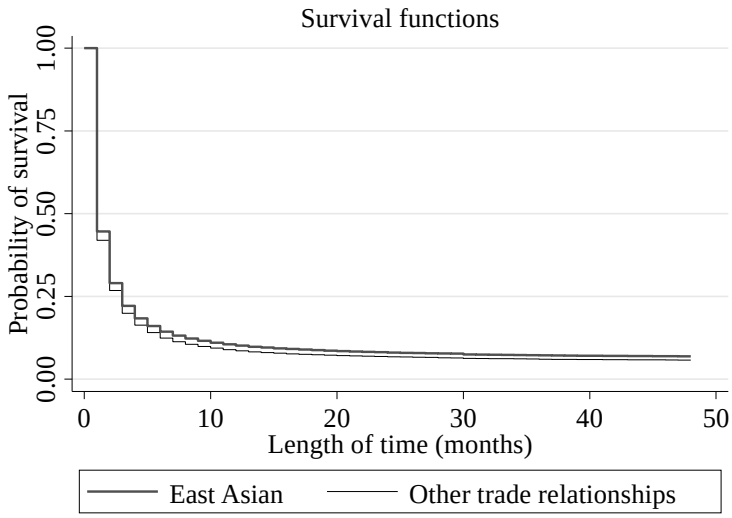
Comparing the survival rates between East Asian and other trade, we observe that the survival rates are lower over time for East Asian trade relationships of non-manufactured goods compared to the corresponding other trade relationships. In contrast, the survival rates are obviously higher over time for East Asian trade relationships than other trade relationships in the case of manufactured parts and components and capital goods (both classified under the machinery sector). This contrasting pattern suggests that East Asian network trade relationships tend to live longer.

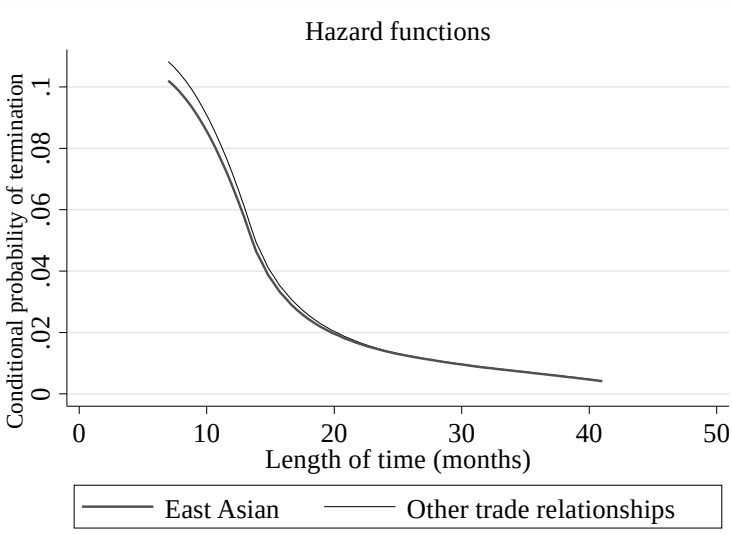
The equality of the survival functions between East Asian and other trade relationships, for each sector and product-stage category, is statistically checked using the log-rank test, for which the p values for the test statistics are reported in the rightmost column of Table 5. The p values indicate that the survival function for East Asian trade relationships is statistically different than that for other trade relationships for each sector and product-stage category. The East Asian network trade relationships that are of interest to us live longer than other trade relationships to a statistically significant degree.

Focusing on network trade under our narrow definition, the upper-left graph of Figure 2 depicts comparisons of the survival functions of the trade relationships of manufactured parts and components between East Asian and other trade. The shapes of the survival functions are downward sloping with a decreasing slope, indicating that a substantial portion of transactions terminated within a short period of time, as mentioned above.

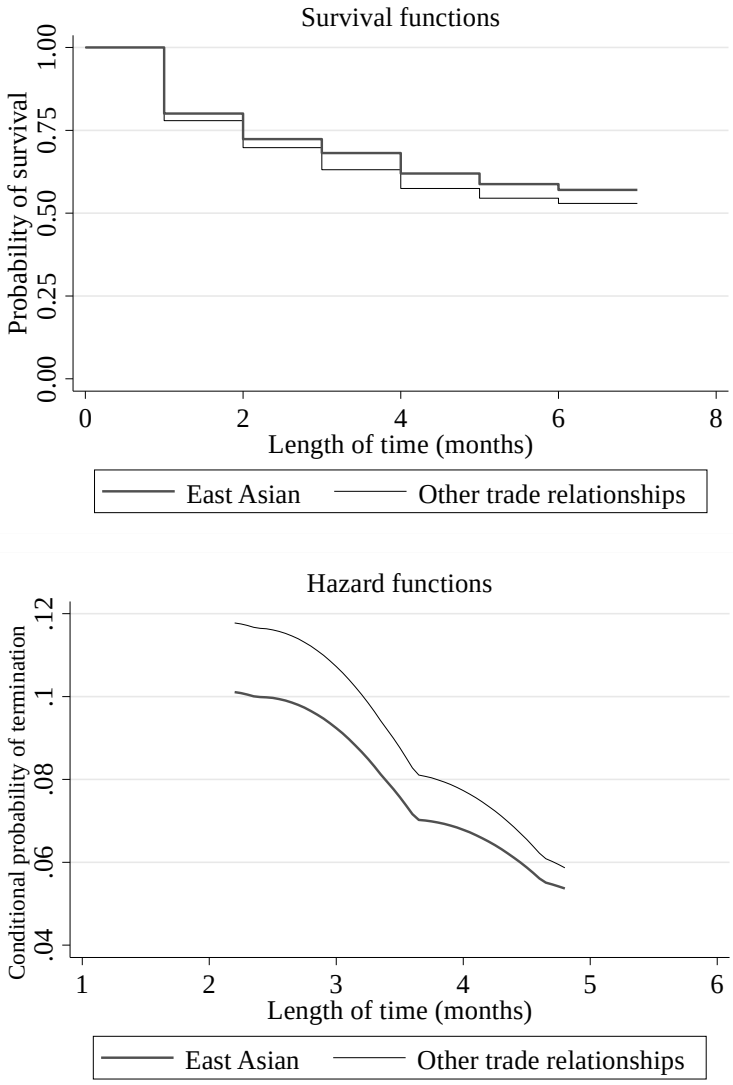
Figure 2. Kaplan-Meier Estimates of Survival and Hazard Functions: Comparison between East Asian and Other Trade Relationships of Manufactured Parts and Components

Normal period, January 2016–December 2019





COVID-19 period, January 2020–June 2020



Notes: The survival rate is the probability of continued trading once a transaction (i.e. spell) is launched. The hazard rate is the probability of termination conditional on continued trading until time $t-1$. 'East Asia' is defined as 16 economies, comprising AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

The upper-right graph of Figure 2 depicts the corresponding hazard function, which is estimated using the usual smoothing Kernel (epanechnikov) technique with a limited graphing range. The hazard function is given by

$$h(t) = Pr(T = t|T \geq t).^{10}$$

[10] The survival and hazard functions are just alternative ways to express the same underlying failure process.

The hazard rate in our study is the probability of termination conditional on the continued trading until time $t-1$. The shapes of the estimated hazard functions indicate that the conditional probability of termination stands at a high level in the earlier months but sharply declines once a transaction lasts for a certain period. The higher survival of the East Asian network trade relationships appears to be attributable to their lower conditional probability of termination within the first 20 months of newly launched transactions.

Table 6 shows the estimated survival rates, as in Table 5, but for the period under the COVID-19 shock, from January 2020 to June 2020. We focus on examining the trade relationships that existed in December 2019 and ignore transactions that emerged in and beyond January 2020. Since our data set covers up to June 2020 at the latest, the survival rates are reported at the first to the sixth month from December 2019 in which a transaction was active. The difference between the number of all spells and the number of disrupted spells corresponds to the spells that continued to be active in transactions from December 2019 to June 2020 even amidst the COVID-19 shock. The proportion of the lasting spells in the total number of spells is equal to the survival rate reported at the sixth month, June 2020.

Table 6. Estimated Kaplan-Meier Survival Rates, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships in the COVID-19 Period, January 2020–June 2020.

	Time since December 2019, in which a transaction was active						Number of observations		
	1st month	2nd month	3rd month	4th month	5th month	6th month	All spells	Disrupted spells	Log-rank test
	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20			Pr>chi2
Non-manufactured goods									
Primary goods									
East Asian trade	0.67	0.55	0.50	0.43	0.39	0.36	7,397	4,704	0.0000
Other trade	0.71	0.61	0.54	0.48	0.44	0.42	30,247	17,600	
Intermediate processed goods									
East Asian trade	0.73	0.61	0.56	0.50	0.46	0.44	12,843	7,242	0.0000
Other trade	0.75	0.66	0.59	0.53	0.50	0.48	49,933	26,163	
Consumption goods									
East Asian trade	0.72	0.60	0.55	0.47	0.44	0.42	44,377	25,896	0.0000
Other trade	0.76	0.67	0.60	0.53	0.49	0.48	183,475	96,202	
Manufactured goods except machinery									
Intermediate processed goods									
East Asian trade	0.73	0.63	0.58	0.51	0.47	0.45	149,720	82,499	0.0000
Other trade	0.74	0.65	0.58	0.52	0.49	0.47	483,348	256,953	
Consumption goods									
East Asian trade	0.76	0.67	0.61	0.53	0.49	0.48	89,398	46,834	0.1790
Other trade	0.77	0.68	0.61	0.52	0.49	0.47	308,078	162,608	
Machinery goods									
Manufactured parts & components									
East Asian trade	0.80	0.72	0.68	0.62	0.59	0.57	68,456	29,421	0.0000
Other trade	0.78	0.70	0.63	0.57	0.55	0.53	191,947	90,319	
Capital goods									
East Asian trade	0.73	0.64	0.59	0.52	0.49	0.47	72,705	38,645	0.0000
Other trade	0.70	0.60	0.53	0.47	0.44	0.43	213,401	121,769	
Consumption goods									
East Asian trade	0.74	0.64	0.59	0.51	0.48	0.46	18,725	10,203	0.0000
Other trade	0.73	0.64	0.57	0.48	0.46	0.44	60,580	33,904	

Note: See the notes for Table 5.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Looking at the survival rates at the sixth month, the rate is strikingly high for trade relationships of manufactured parts and components for both East Asian and other trade, compared to other sectors and product-stage categories. Of particular note is the 57% of East Asian network trade relationships of manufactured parts and components that were active in transactions as of December 2019 and continued to be active (at least) until June 2020 despite the COVID-19 shock.

Comparing the survival rates between East Asian and other trade, a similar contrasting pattern as in the normal period (Table 5) can be detected: the survival rates are lower for East Asian trade compared to other trade in the case of non-manufactured goods, whereas they are obviously higher for East Asian trade than other trade in the case of machinery goods. The contrasting over-time trend in the survival rates indicates that East Asian network trade relationships tend to live longer even amidst the COVID-19 shock. And the difference in the survival functions between East Asian and other trade is statistically confirmed by the log-rank test except for the consumption goods of other manufacturing sectors than machinery.

Focusing on network trade under our narrow definition, the lower portion of Figure 2 presents comparisons of the survival and hazard functions estimated for the trade relationships of manufactured parts and components between East Asian and other trade. The higher survival rate for East Asian trade relationships appears to be maintained exceptionally at the third month, March 2020, in which a significant portion of transactions was disrupted outside of East Asia. Reflecting this, we detect a turning point in the estimated hazard curve between the third and fourths months, between March and April 2020.

4.2. Cox proportional hazards estimation: Conditional probability of termination

To confirm the higher survival rate of network trade relationships in East Asian trade than other trade, we estimate the Cox proportional hazards model for the conditional probability of termination. The semi-parametric Cox proportional hazards model asserts that the hazard rate for spell m is

$$h(t|\boldsymbol{X}_m) = h_0(t)\exp(\boldsymbol{X}_m\boldsymbol{\beta}),$$

where $\boldsymbol{X}_m$ denotes a vector of covariates specific to spell m, and coefficients $\boldsymbol{\beta}$ are to be estimated. Although the Cox model is a continuous model, the survival data in our study are discrete from month to month, and multiple failures, or terminations of spells, are observed at the same time (month). We therefore employ the Breslow approximation in treating such tied failures.

We assume that covariates multiplicatively shift the baseline hazard function $h_0(t)$, which is common to all of the spells under study and is left unspecified. Note that the hazard rate for a spell is equal to the baseline hazard when the values of all covariates are set to zero. The exponentiated coefficient is interpreted as the ratio of hazard rates that is known as the 'hazard ratio' for a one-unit change in the covariate of concern. A hazard ratio estimated to be greater (or less) than one indicates that the covariate increases (decreases) the conditional probability of termination. A hazard ratio equal to one indicates that the covariate has no impact on the conditional probability of termination. Of our particular interest is the estimated hazard ratio for the East Asian dummy variable, which takes one if a transaction involves an East Asian country either on the exporter or importer side or both, and is zero otherwise. The hazard ratio for the East Asian dummy is expected to be less than one.

We estimate the Cox model separately for the normal period, from January 2016 to December 2019, and the COVID-19 period, from January to June 2020. For the COVID-19 period, we focus on examining the trade relationships that were active in transactions in December 2019, as in the previous subsection. To estimate the Cox model, the survival data is split at every observed failure time, or every month, for respective spells. We include time (month) dummy variables to control for worldwide time-specific idiosyncratic shocks in the case of the estimation for the normal period.

We also control for spell-specific characteristics that may influence the conditional probability of termination: we control for the initial transaction size by including the logged value of trade in the first month of the spell. A transaction that started with a smaller value would be economically less important and may face a greater risk of disruption. In addition, considering the prevalence of multiple spells for a certain trade relationship, we control for prior experience of disruption. We include a dummy variable that takes a value of one if there was a former disruption(s) before the current spell was started, and is zero otherwise, at the exporter-importer-product level. A trade relationship that recovered after some period of no transaction may be less likely to be disrupted again, owing to accumulated information about the trade counterpart market.

Table 7 shows the Cox proportional hazards estimates on the conditional probability of the termination of network trade relationships. The estimated coefficients are expressed as hazard ratios, accompanied by robust standard errors

clustered by HS six-digit product as reported in parentheses. Asterisks attached to the hazard ratios indicate the significance (different from one) at the 0.1%, 1%, and 5% levels. The estimates for the normal period are reported in the first two columns of the table. For the trade relationships of network trade under both the narrow and broad definitions, the hazard ratio for the East Asian dummy is estimated to be less than one at the 0.1% significance level, after controlling for other covariates. Considering the network trade relationships outside of East Asia as a baseline, East Asian network trade relationships have a 1.5% lower hazard rate under the narrow definition (i.e. manufactured parts and components of machinery goods) and a 0.9% lower hazard rate under the broad definition (i.e. all machinery goods). In other words, for East Asian network trade, once a transaction is launched, it is 0.9%–1.5% less likely to be disrupted compared to those outside the region. The hazard ratios for other covariates are all estimated as expected in terms of sign and significance.

Table 7. Cox Proportional Hazards Estimates on the Conditional Probability of Termination of Network Trade Relationships

Period	Normal		COVID			
Definition of network trade	Narrow	Broad	Narrow		Broad	
Variables	[1]	[2]	[3]	[4]	[5]	[6]
East Asian dummy	0.985***	0.991***	0.994	1.000	0.996	1.002
	(0.00240)	(0.00149)	(0.00710)	(0.00698)	(0.00427)	(0.00427)
ln(initial trade value)	0.959***	0.966***	0.945***		0.959***	
	(0.00109)	(0.000768)	(0.00205)		(0.00132)	
ln(trade value in December 2019)				0.938***		0.951***
				(0.00212)		(0.00138)
Age (consecutive months in transaction)			0.926***	0.927***	0.927***	0.928***
			(0.000407)	(0.000423)	(0.000349)	(0.000355)
Dummy for prior disruption	0.657***	0.677***	0.595***	0.603***	0.606***	0.611***
	(0.00141)	(0.00273)	(0.00611)	(0.00627)	(0.00411)	(0.00415)
Time (month) dummies	YES	YES	NO	NO	NO	NO
Number of all spells	2,774,895	7,565,721	260,403	260,403	625,814	625,814
Number of disrupted spells	2,514,492	6,939,907	119,740	119,740	324,261	324,261
Time at risk	12,320,359	29,210,272	1,254,343	1,254,343	2,812,815	2,812,815
Log likelihood	-35,711,693	-98,877,612	-1,389,772	-1,389,392	-3,749,735	-3,748,869

Notes: The dependent variable is the hazard rate, which is the probability of termination conditional on continued trading until time $t-1$. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

The estimates for the COVID-19 period are reported in the third to sixth columns of Table 7. When examining the COVID-19 period, we limit our attention to trade relationships that existed in December 2019 and are interested in analysing their conditional probabilities of termination in January 2020 and beyond amidst the shock. We thus do not need to control for time-specific effects in the estimation of the COVID-19 period, unlike in the case of the normal period. Nevertheless, the duration of continued trading prior to December 2019 would decrease the probability of termination in the later months. In this regard, we include the age variable, which is defined at the exporter-importer-product level as the number of consecutive months in transaction until December 2019. In addition, to control for the initial size of transaction, we consider including the logged value of trade in December 2019, the beginning month of the data set for the COVID-19 period, as well as that in the first month of the spell (which is typically some time before December 2019).

In the case of the COVID-19 period, the hazard ratio for the East Asian dummy is estimated to be statistically insignificant in all specifications irrespective of the narrow or broad definition of network trade. Amidst the COVID-19 shock, unlike during the normal period, the conditional probability of termination of the East Asian network trade relationships is not statistically different than that of network trade outside the region. In other words, despite the higher survival rates summarised in Table 6 in the previous subsection, East Asian network trade relationships do not appear to live longer amidst the COVID-19 shock to a statistically significant degree, after controlling for possible covariates.

4.3. Probability of recovering from disrupted trading

Next, we analyse the probability of recovering after a transaction at the exporter-importer-product level was terminated. To do so, we estimate the Kaplan-Meier failure function, $F(t)$, which equals $1 - S(t)$, where $S(t)$ is the survival function. Focusing on examining trade relationships that disrupted at some point in time during the sample period, the failure rates in our study are the probability of recovering from disrupted trading. Note that here we do not need to care about the left-censoring issue of the data set because we focus on trade relationships that had been active in transactions for some period and then had been disrupted. We treat

multiple spells of disrupted trading for a certain trade relationship as independent of each other.

Table 8 shows the estimated Kaplan-Meier failure rates for East Asian trade relationships compared to other trade relationships by sector and product-stage category in the normal period. The first six columns of the table summarise the failure rates at the 1st, 2nd, 4th, 8th, 16th, and 32nd month since a (former) transaction was terminated or disrupted. Overall, the failure rates at the first month range from 32% to 37%, and the rates further rise to 62%–68% at the fourth month. About one-third of disrupted trade relationships recovered within a month after the disruption, and two-thirds recovered within four months. Comparing the failure rates between East Asian and other trade, we observe that the failure rates for East Asian trade relationships are equal to or higher than the corresponding other trade relationships in each sector and product-stage category. It is especially noticeable that the East Asian network trade relationships of manufactured parts and components tend to live longer. The difference in the failure functions between East Asian and other trade relationships for each sector and product-stage category is statistically confirmed by the log-rank test at the 0.1% significance level, as reported in the rightmost column of the table.

Table 8. Estimated Kaplan-Meier Failure Rates, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships in the Normal Period

	Time since a transaction was disrupted						Number of observations		Log-rank test
	1st month	2nd month	4th month	8th month	16th month	32nd month	All spells	Restored spells	Pr>chi2
Non-manufactured goods									
Primary goods									
East Asian trade	0.33	0.48	0.62	0.74	0.83	0.88	112,564	90,246	0.0007
Other trade	0.32	0.47	0.62	0.74	0.83	0.88	418,001	334,107	
Intermediate processed goods									
East Asian trade	0.35	0.51	0.66	0.78	0.86	0.90	164,776	136,286	0.0000
Other trade	0.35	0.51	0.66	0.77	0.84	0.89	558,154	457,110	
Consumption goods									
East Asian trade	0.35	0.51	0.66	0.77	0.85	0.90	527,587	434,242	0.0000
Other trade	0.35	0.50	0.65	0.76	0.84	0.89	1,836,859	1,498,476	
Manufactured goods except machinery									
Intermediate processed goods									
East Asian trade	0.35	0.51	0.66	0.77	0.85	0.90	1,835,140	1,507,558	0.0000
Other trade	0.34	0.50	0.65	0.76	0.84	0.89	5,814,811	4,721,934	
Consumption goods									
East Asian trade	0.34	0.50	0.65	0.77	0.86	0.91	918,051	762,947	0.0000
Other trade	0.34	0.49	0.64	0.76	0.85	0.90	3,026,665	2,483,292	
Machinery goods									
Manufactured parts & components									
East Asian trade	0.37	0.53	0.68	0.79	0.87	0.92	598,748	505,028	0.0000
Other trade	0.35	0.50	0.65	0.77	0.85	0.90	1,915,744	1,580,878	
Capital goods									
East Asian trade	0.34	0.49	0.64	0.76	0.85	0.90	839,174	689,893	0.0000
Other trade	0.32	0.47	0.62	0.74	0.83	0.89	2,705,153	2,175,463	
Consumption goods									
East Asian trade	0.34	0.49	0.64	0.75	0.84	0.89	207,106	168,737	0.0000
Other trade	0.33	0.48	0.62	0.74	0.83	0.88	673,982	543,429	

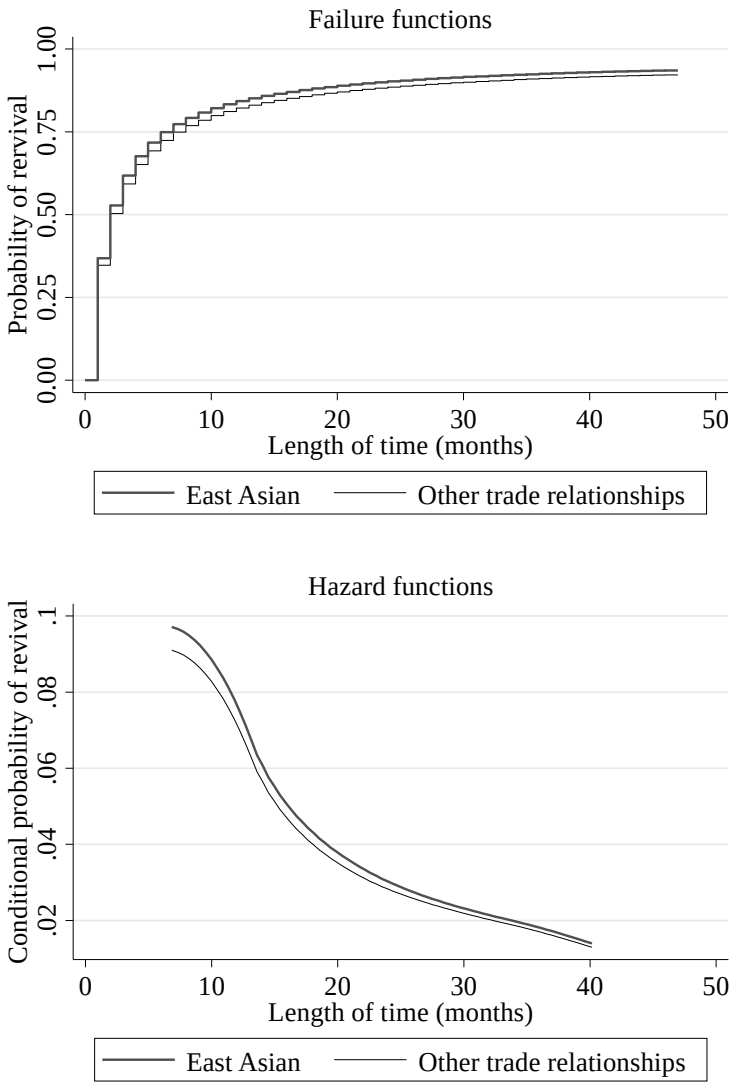
Notes: The failure rate here is the probability of recovering once a transaction (i.e. spell) is disrupted. The p-value in the rightmost column indicates whether the failure function for East Asian trade is statistically different than that for other trade. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Focusing on network trade under our narrow definition, the upper-left graph of Figure 3 depicts the failure functions of the trade relationships of manufactured parts and components compared between East Asian and other trade. The upper-right graph of the figure depicts the corresponding hazard functions. The hazard rate here is the probability of recovering from disrupted trading conditional on being inactive in transactions until time $t-1$. The shapes of the estimated hazard

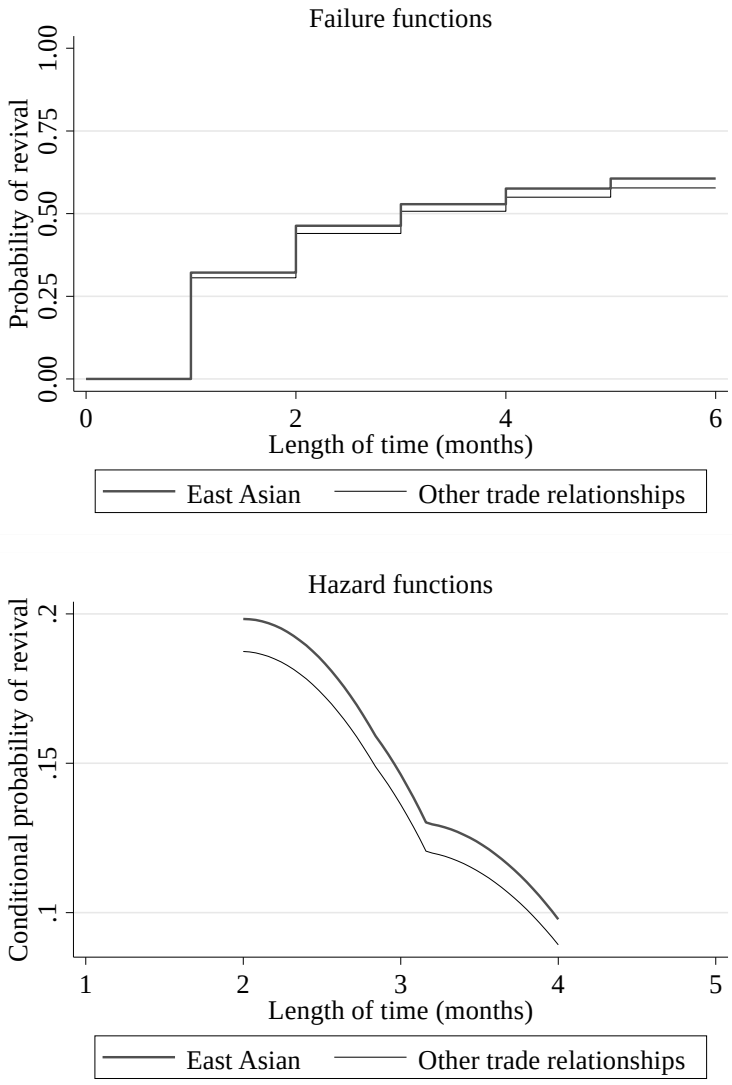
functions indicate that the conditional probability of revival stands at a high level in the earlier months but steadily declines as a transaction continues to be inactive. The higher revival of East Asian network trade relationships appears to be attributable largely to their higher conditional probability of recovering from disrupted trading within the earlier months.

Figure 3. Kaplan-Meier Estimates of Failure and Hazard Functions: Comparison between East Asian and Other Trade Relationships of Manufactured Parts and Components

Normal period



COVID-19 period



Notes: The failure rate is the probability of recovering once a transaction (i.e. spell) is disrupted. The hazard rate is the probability of recovering from disruption conditional on being inactive until time $t-1$. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

Table 9 shows the failure rates, as in Table 8, but for the COVID-19 period, focusing on trade relationships that existed in December 2019 and were disrupted once or more in and beyond January 2020. It is noteworthy that there is a distinct difference in the failure rates between East Asian and other trade in the manufactured parts and components and capital goods of the machinery sector, unlike other sector and product-stage categories. The difference in the failure functions between East Asian and other trade is statistically confirmed by the log-rank test at the 5% or lower significance level only for manufactured parts and components and capital goods of machinery. East Asian network trade relationships of manufactured parts and components and capital goods were disrupted amidst the COVID-19 shock but recovered at a relatively high rate compared to the corresponding transactions outside the region. In addition, focusing on network trade under our narrow definition, the lower set of graphs in Figure 3 depict the failure and hazard functions estimated for the trade relationships of manufactured parts and components compared for East Asian and other trade.

Table 9. Estimated Kaplan-Meier Failure Rates, by Sector and Production-stage Category: Comparison between East Asian and Other Trade Relationships in the COVID-19 Period

	Time since a transaction was disrupted					Number of observations		Log-rank test
	1st month	2nd month	3rd month	4th month	5th month	All spells	Restored spells	Pr>chi2
Non-manufactured goods								
Primary goods								
East Asian trade	0.28	0.41	0.48	0.52	0.55	14,187	6,443	0.0547
Other trade	0.28	0.40	0.47	0.51	0.54	53,414	23,613	
Intermediate processed goods								
East Asian trade	0.31	0.44	0.51	0.55	0.58	21,281	10,166	0.3739
Other trade	0.31	0.45	0.51	0.56	0.58	73,092	35,497	
Consumption goods								
East Asian trade	0.29	0.43	0.49	0.54	0.56	69,336	32,534	0.6551
Other trade	0.30	0.43	0.49	0.53	0.56	242,173	114,117	
Manufactured goods except machinery								
Intermediate processed goods								
East Asian trade	0.30	0.44	0.50	0.55	0.58	236,444	112,362	0.3743
Other trade	0.30	0.44	0.50	0.55	0.57	744,357	354,572	
Consumption goods								
East Asian trade	0.29	0.42	0.48	0.53	0.56	120,545	56,244	0.0880
Other trade	0.29	0.42	0.49	0.53	0.56	400,239	189,659	
Machinery goods								
Manufactured parts & components								
East Asian trade	0.32	0.46	0.53	0.58	0.61	77,927	39,273	0.0000
Other trade	0.31	0.44	0.51	0.55	0.58	248,344	120,115	
Capital goods								
East Asian trade	0.29	0.43	0.49	0.54	0.57	106,256	50,247	0.0000
Other trade	0.28	0.41	0.48	0.52	0.55	345,716	158,001	
Consumption goods								
East Asian trade	0.29	0.43	0.49	0.54	0.56	26,862	12,623	0.6088
Other trade	0.29	0.42	0.49	0.53	0.56	87,423	41,423	

Note: See the notes for Table 8.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

4.4. Cox proportional hazards estimation: Conditional probability of revival

To confirm the higher failure rate of network trade relationships in East Asian trade than other trade, we estimate the Cox proportional hazards model for the conditional probability of recovering from disrupted trading in a similar vein to the analysis in section 4.2. In estimating the Cox model, we include time (month) dummy variables to control for time-specific idiosyncratic shocks. In addition to controlling for the prior experience of disruption, we control for the size of the last transaction just before being disrupted by including the logged value of the last transaction. A transaction disrupted even with a larger value would be economically important and may potentially have a higher probability of revival.

Table 10 shows the Cox proportional hazards estimates on the conditional probability of the revival of network trade relationships. The estimates for the normal period are reported in the upper portion of the table and those for the COVID-19 period in the lower portion. As for the normal period, the first and third columns show the hazard ratios estimated using the data set of all spells, i.e. all disruption events, observed during the sample period, whilst the second and fourth columns show the estimates based only on the data on the first spells, i.e. the first-observed disruptions, of the respective trade relationships at the exporter-importer-product level. The hazard ratio for the East Asian dummy is estimated to be greater than one at the 0.1% significance level after controlling for other covariates, for trade relationships of network trade under both the narrow and broad definitions. Taking network trade relationships outside of East Asia as a baseline, East Asian network trade relationships have a 3.9%–4.3% higher hazard rate. When focusing exclusively on the first spells, East Asian network trade relationships have a 7.1%–8.7% higher hazard rate.

Table 10. Cox Proportional Hazards Estimates on the Conditional Probability of Revival of Network Trade Relationships

Period	Normal			
Definition of network trade	Narrow		Broad	
Sample	All spells	First spells only	All spells	First spells only
Variables	[1]	[2]	[3]	[4]
East Asian dummy	1.043***	1.087***	1.039***	1.071***
	(0.00302)	(0.00499)	(0.00194)	(0.00329)
ln(the last trade value before disruption)	1.021***	1.032***	1.018***	1.026***
	(0.00115)	(0.00179)	(0.000828)	(0.00130)
Dummy for prior disruption	2.437***		2.539***	
	(0.00969)		(0.00876)	
Time (month) dummies	YES	YES	YES	YES
Number of all spells	2,514,492	575,860	6,939,907	1,664,983
Number of restored spells	2,085,906	420,251	5,663,428	1,174,265
Time at risk	13,973,335	6,160,081	41,183,280	18,909,363
Log likelihood	-29,285,152	-5,304,461	-79,750,845	-14,929,385

Period	COVID					
Definition of network trade	Narrow			Broad		
Sample	All spells		First spells only	All spells		First spells only
Variables	[5]	[6]	[7]	[8]	[9]	[10]
East Asian dummy	1.035***	1.028***	1.031***	1.024***	1.016***	1.020***
	(0.00589)	(0.00586)	(0.00662)	(0.00368)	(0.00365)	(0.00422)
ln(the last trade value before disruption)	1.024***	1.026***	1.031***	1.021***	1.023***	1.029***
	(0.00165)	(0.00167)	(0.00182)	(0.00100)	(0.00101)	(0.00109)
Dummy for prior disruption after December 2019	0.473***	0.468***		0.464***	0.461***	
	(0.00243)	(0.00247)		(0.00158)	(0.00160)	
Dummy for prior disruption before December 2019		1.572***	1.218***		1.736***	1.360***
		(0.0240)	(0.0175)		(0.0194)	(0.0155)
Time (month) dummies	YES	YES	YES	YES	YES	YES
Number of all spells	310,465	310,465	119,740	843,957	843,957	324,261
Number of restored spells	158,186	158,186	86,299	417,949	417,949	227,923
Time at risk	706,519	706,519	294,897	1,981,104	1,981,104	840,519
Log likelihood	-1,925,908	-1,924,817	-975,696	-5,099,772	-5,095,614	-2,580,247

Notes: The dependent variable is the hazard rate, which is the probability of recovering from disruption conditional on being inactive until time $t-1$. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

In the COVID-19 period, as in the normal period, the hazard ratio for the East Asian dummy is estimated to be greater than one at the 0.1% significance level after controlling for other covariates in all specifications. Amidst the COVID-19 shock, as well as in normal times, the conditional probability of the revival of East Asian network trade relationships is significantly higher than that of network trade outside the region. Nevertheless, the estimated hazard ratio for the East Asian dummy tends to be smaller in magnitude in the COVID-19 period than in the normal period. To be more precise, in the COVID-19 period, East Asian network trade relationships have a 1.6%–3.5% higher hazard rate when considering all spells and a 2.0%–3.1% higher hazard rate when focusing exclusively on the first spells. This would suggest that the disrupted trade relationships of East Asian network trade were yet to recover at a rate as high as normal, at least as of June 2020.

5. Conclusion

In this paper, we investigated the robustness and resilience of trade relationships in East Asian network trade by conducting a series of survival analyses. In doing so, we made use of up-to-date bilateral merchandise trade data at the HS six-digit product level from January 2016 to June 2020, including the period affected by the COVID-19 shock, on a monthly basis. We focused particularly on examining trade in manufactured parts and components under our narrower definition of network trade and considered trade in capital goods and machinery consumption goods as well under the broader definition.

We detected the robustness of East Asian network trade in normal times, in the sense that the conditional probability of termination is 0.9%–1.5% lower for East Asian network trade relationships with respect to those outside of the region as a baseline after controlling for possible covariates. In the period under the COVID-19 shock, however, the conditional probability of termination is not statistically different between East Asian network trade and extra-regional network trade. Despite the robustness of East Asian network trade in normal times, transactions within East Asian production networks were disrupted amidst the

COVID-19 shock at a rate comparable to the level of network trade outside the region.

In addition, we detected the resilience of East Asian network trade even amidst the COVID-19 shock as well as in normal times. After controlling for possible covariates, the conditional probability of recovering from disrupted trading is 3.9%–4.3% and 1.6%–3.5% higher for East Asian network trade compared to extra-regional trade in the normal and COVID-19 period, respectively. The difference in the conditional probability of revival between East Asian and extra-regional network trade is relatively small in the COVID-19 period. The East Asian network trade relationships that were disrupted in the face of the COVID-19 shock appear to have not yet recovered at a rate as high as normal, at least as of June 2020, the end month of our latest data set. Still, more noteworthy is the evidence indicating that East Asian network trade remains more resilient than extra-regional network trade, even amidst the COVID-19 shock.

We provided a new set of empirical evidence suggesting the robustness of East Asian network trade in normal times and its resilience even amidst the COVID-19 shock. Our findings can be regarded as evidence against the renewed argument for the end of internationalised production and turning inwards. Governments should not adopt policies that distort internationalised production and trade. Rather, governments should foster the development of international production networks as a basis for the economic growth of the region to bring greater efficiency, expand the production frontier, and facilitate technology and knowledge diffusion and spillovers.

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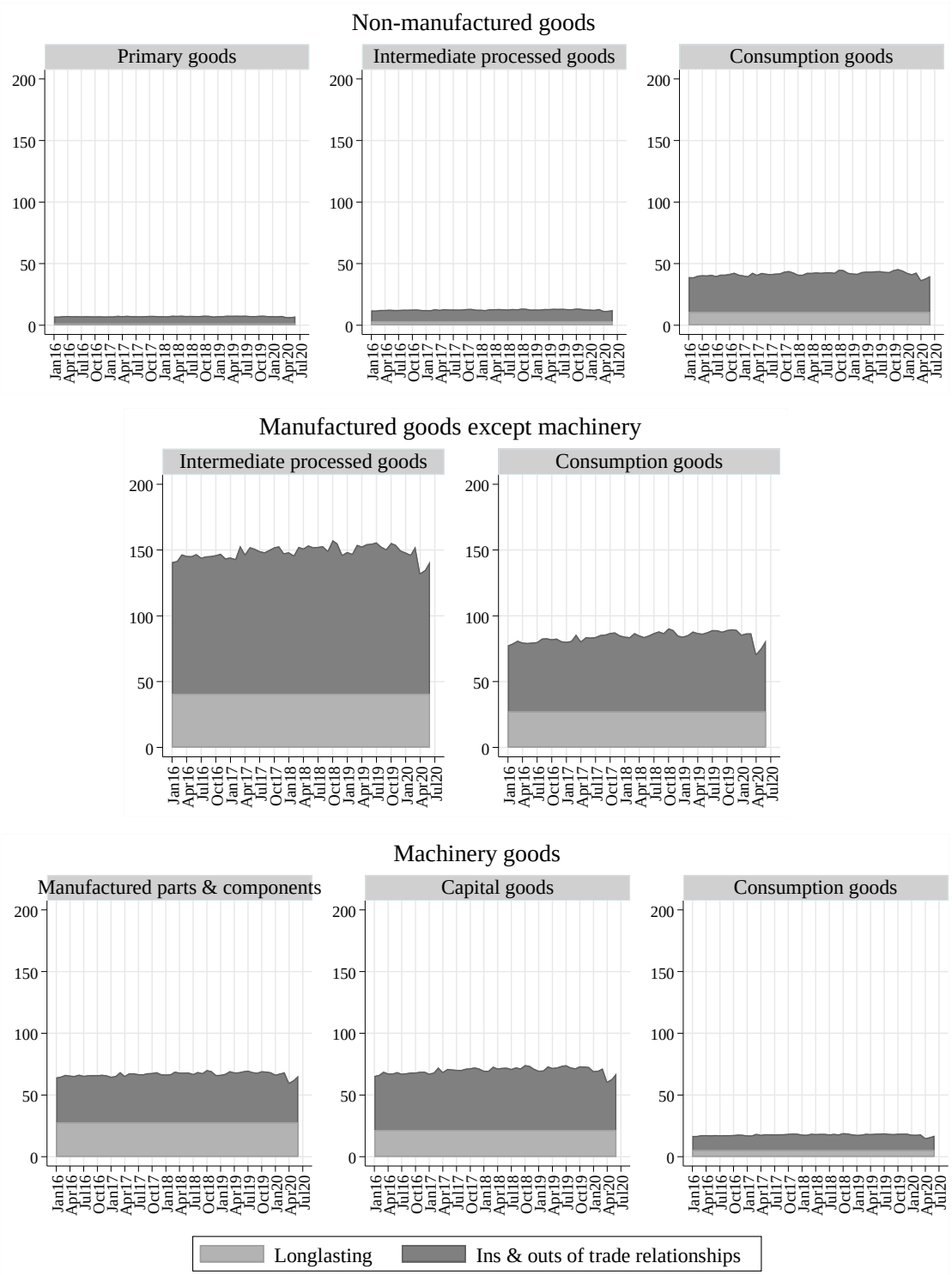
Appendix

Table A1. Countries and Regions Reporting Trade Statistics from January 2016 to June 2020

Canada	Hong Kong	Pakistan
Czechia	Hungary	Paraguay
Denmark	Iceland	Philippines
Ecuador	Ireland	Poland
El Salvador	Japan	Serbia
Estonia	Lithuania	South Africa
Finland	Luxembourg	Switzerland
Georgia	New Zealand	United Kingdom
Germany	North Macedonia	United States
Greece	Norway	

Source: Author.

Appendix Figure A1. Changes in the Number of Trade Relationships, by Sector and Production-stage Category: East Asian Trade Only ('000)



Notes: See the notes for Figure 1. 'East Asia' is defined as 16 economies, comprised of AMS, China, Japan, the Republic of Korea, Australia, New Zealand, and India.
Source: Author's calculations using monthly trade data (UN Comtrade) and the production-stage indicator (RIETI-TID).

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