Deepening and Widening of Production Networks in ASEAN*

Ayako Obashi
Toyo University and Keio University
5-28-20 Hakusan, Bunkyo-ku
Tokyo 112-8606, Japan
obashi@toyo.jp

Fukunari Kimura
Keio University and Economic Research Institute for ASEAN and East Asia (ERIA)
2-15-45 Mita, Minato-ku
Tokyo 108-8345, Japan
fkimura@econ.keio.ac.jp

Abstract
This paper assesses the recent widening and deepening of machinery production networks in ASEAN by using highly disaggregated international trade data over 2007–13. Based on both traditional trade value data analysis and a novel approach to the diversification of exported products and destinations, we confirm the steady development of back-and-forth trade links, notably with East Asian partners, centering on Singapore and Thailand. In addition to the five ASEAN forerunners, Vietnam is an increasingly active player in such networking. Although their degree of participation is still limited, Cambodia, Lao PDR, and Myanmar also show signs of joining production networks.

1. Introduction

Cross-border fragmentation of the production process into geographically separated stages, or *global production sharing*, has evolved into a network of back-and-forth trade links in East Asia and other parts of the world. The development of such international production networks is reflected in an expansion of international trade, especially in trade of intermediate goods. To assess the extent and depth of these production networks, previous studies have attempted to quantify the magnitude and reveal the patterns and determinants of trade taking place within the networks (for an overview of the existing approaches used to capture trade within the networks, see Athukorala 2011). In line with this literature, we examine to what degree less-developed ASEAN countries have also

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started to become involved in international production networks. We also look at how already-active players in production networks have deepened their participation, by making full use of product-level trade data with a focus on the product and destination diversification in each countries' exports of intermediate goods.

Participation in production networks is crucial in the development strategies of ASEAN countries. ASEAN and surrounding East Asian countries entered an era of international production/distribution networks (Ando and Kimura 2005), or the "second unbundling" (Baldwin 2011), in the mid-1980s. Unlike Japan, the Republic of Korea, and Taiwan in the 1950s to 1970s—when much more gradual industrialization with trade protection was at the center of their development strategies—Southeast Asian countries and China can utilize the mechanics of production fragmentation, particularly in the machinery industry, to jump-start and upgrade industrialization. Although we can also observe the development of production networks in other parts of the world, including Latin America and Eastern Europe, ASEAN and East Asian countries are the most advanced in terms of geographical extension and the sophistication of their production networks. However, because ASEAN countries have different historical backgrounds and economic systems, and are at different stages of development, the degree of participation in production networks differs widely across countries. Latecomers to ASEAN, such as Cambodia, Lao People's Democratic Republic (PDR) and Myanmar, are still in the initial stages of participating in production networks. Vietnam, the Philippines and Indonesia are struggling for deeper involvement in production networks, while Thailand, Malaysia, and Singapore are seeking pathways toward more sophisticated means of utilizing production networks. Indeed, how to take full advantage of the mechanics of production networks is a central theme of industrial development plans in each country and in ASEAN economic integration, as presented in the ASEAN Economic Community Blueprint (ASEAN 2007) and the Master Plan on ASEAN Connectivity (ASEAN 2010). In view of this, Kimura and Obashi (2010) undertook a thorough survey of this issue using international trade data.

The current paper concentrates on assessing the degree of involvement of ASEAN countries in international production networks in the machinery industry. To explore participation in production networks, we aim to quantify the magnitude of international trade occurring within networks by utilizing highly disaggregated international trade data for machinery parts and components at the Harmonized System (HS) six-digit product level. In so doing, we focus our attention on a key aspect of the increased involvement in production networks: networks of back-and-forth trade links of machinery parts and components, especially inside the East Asian region. In addition to Singapore, Malaysia, Thailand, Indonesia, and the Philippines, Vietnam is an increasingly active player in such production networks. On the other hand, Brunei, Cambodia, Lao PDR, and Myanmar are relatively limited in terms of their integration into production networks, although these countries are expanding their formation of trade links for a wider range of products

with a wider range of trading partners. Specifically, departing from simply looking at the value of exports, we count the number of products exported, the number of destination market countries across products, and the number of product-destination pairs in several informative ways, to reveal the patterns of diversification of exported products and destination markets.

From the perspective of export product and destination diversification, we document that ASEAN countries, centering on Singapore and Thailand, have widened the range of products exported and the geographic scope of their respective destination markets. Even more strikingly, Singapore, Thailand, and other already-active players have deepened their participation in production networks by exporting already-exported products to new destination countries to which these countries had not previously provided these products. Production networks are widening by involving more exporters of products, and are also deepening by increasing the number of non-zeros in the product-level bilateral trade matrix.

The remainder of this paper proceeds as follows: Section 2 begins by comparing ASEAN countries and other countries by using the proportion of machinery parts and components in total exports and imports of manufactured goods. Section 3 examines the degree of participation of ASEAN countries in international production networks in the machinery industry, from the perspective of export product and destination diversification. To help us to understand the observed patterns of export product and destination diversification, Section 4 offers a statistical analysis of the probability that a product is exported from a particular origin country to a particular destination country, applying gravity logic to the incidence of zeros in terms of global production sharing. Finally, Section 5 concludes.

2. Preliminary analysis using trade value data

Given the fact that ASEAN countries and other East Asian countries are, and have been, highly dependent on trade in machinery, we focus on the machinery industry to explore the involvement of ASEAN countries in international production networks. In order to assess the degree of involvement in machinery production networks, we aim to quantify the magnitude of international trade occurring within these networks. Trade within these networks encompasses the export of intermediate goods and semi-finished products, and also includes the export of finished products assembled or manufactured, using imported intermediate inputs.

To quantify the magnitude of trade within production networks for less-developed ASEAN countries, as well as the forerunners, we make full use of international trade data from the UN Comtrade database, which is publically available for a wide range of

countries. From the standpoint of reliability, we use import statistics throughout the paper (even when we analyze a country's exports). Import statistics are regarded as more reliable because a country of origin is more closely verified because of tariff regulations, and the final destination may not be known at the time of export.[1] To count the number of products traded and the number of trading partner countries in a consistent manner (in Sections 3 and 4), we try to avoid any issues arising from mergers or branching of product codes due to classification updates. We therefore construct a data set for bilateral trade flows at the six-digit level of the 1996 version of the HS product classification for both 2007 and 2013. The data set consists of 139 countries, including all East Asian countries of interest.[2] Using the data set, we analyze all potential bilateral trade flows, including zero flows, between 19,182 (= 139 × 138) exporter–importer pairs at the product level.[3]

Based on the HS classification, manufactured goods range from HS 28 to HS 92. Among them, machinery includes all goods classified as part of general machinery (HS 84), electric machinery (HS 85), transport equipment (HS 86–89) and precision machinery (HS 90–92). We group respective HS product codes at the most disaggregated level into machinery parts and components, and final products.[4]

Let us begin by comparing countries using the proportion of machinery, in particular machinery parts and components, in their total exports and imports of manufactured goods. The higher the percentage of machinery parts and components in exports or imports, the more deeply a country is considered to be integrated into machinery production networks relative to trade in other manufacturing sectors. In Figure 1, a pair of stacked bars shows the percentages of machinery in a country's manufacturing exports (left-hand bar) to, and

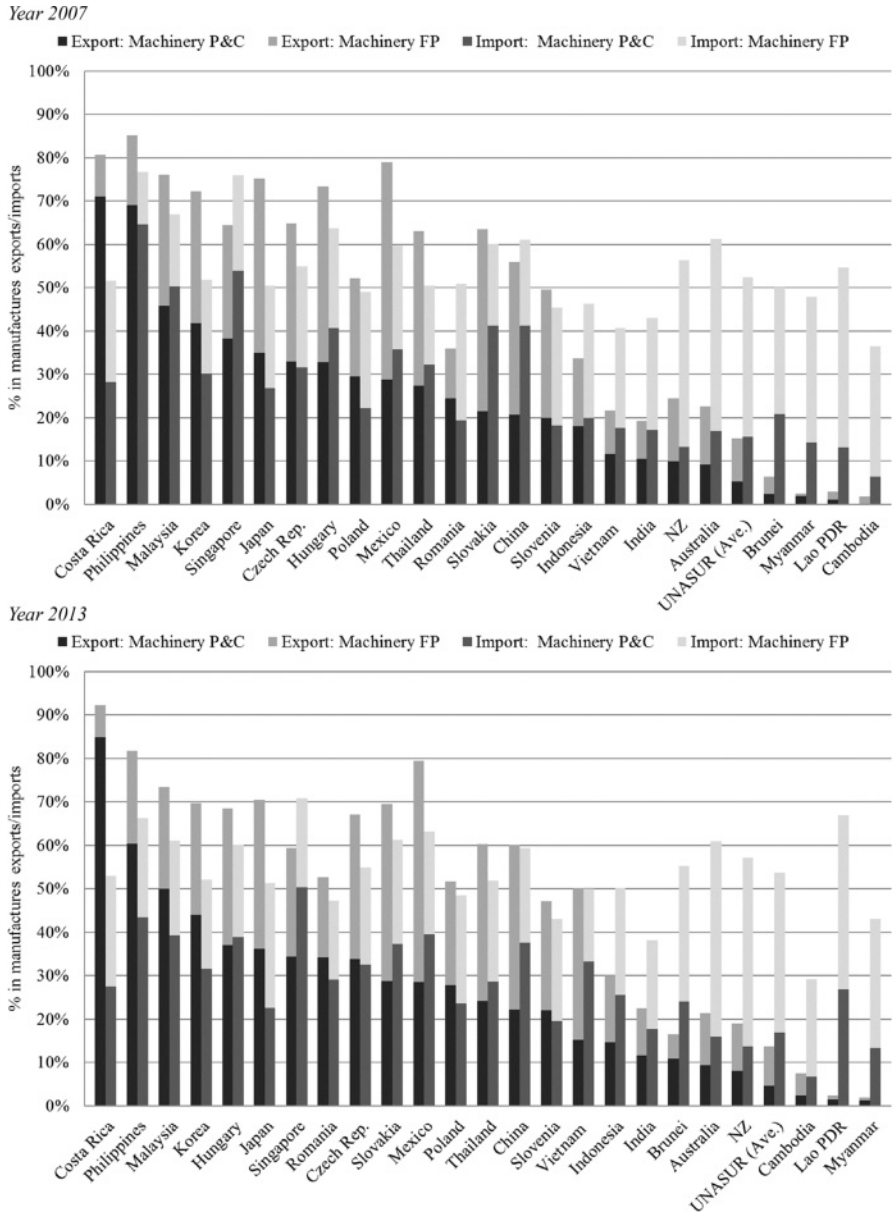
1 By using import statistics, we avoid the need to tackle data issues such as the one emerging from Hong Kong's important role in re-exporting goods from China to the rest of the world (and in the opposite direction).

2 East Asia here is defined as the so-called ASEAN+6, namely, ASEAN member countries, the People Republic of China (hereafter, China), Japan, the Republic of Korea, Australia, New Zealand (hereafter, NZ) and India. Because the statistical territory of China's external trade statistics coincides with its customs territory that does not cover separate customs territories of Hong Kong and Macau, the UN Comtrade database (our source of data) practically treats mainland China and those Special Administrative Regions separately. We include only mainland China as "China" and exclude the Special Administrative Regions from our data set.

3 For the details of the construction of our data set, see Obashi and Kimura (2016). The total value of bilateral trade covered by our data set accounts for more than 90 percent of annual total imports to all reporter countries available in the UN Comtrade database from all partner countries for which International Standards Organization (ISO) 3166-1 alpha-3 country codes are assigned, both for 2007 and 2013.

4 See Kimura and Obashi (2010) for the list of machinery parts and components at the HS four- and six-digit level for different versions of the HS classification. Because some parts and components used in the machinery industry that ranges from HS 84 to HS 92 are classified under the HS codes other than the machinery industry (e.g., chemical and basic metal products), we would understate the magnitude and diversity of machinery parts and components.

Figure 1. Machinery shares in total manufactures exports to and imports from the world



Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level).*

Note: *We use import statistics to construct a data set for bilateral trade flows at the HS six-digit level, consisting of 139 countries, with a few exceptions. Machinery industries are defined as HS 84–92. Product groupings (e.g., P&C vs FP) follow Kimura and Obashi (2010). See text for more details on the data set construction.*

imports (right-hand bar) from, the rest of the world, respectively. The dark gray portions represent the percentages accounted for by parts and components (labelled as P&C), and the light gray portions represent final products (FP). The bars are in descending order, from left to right, in terms of machinery parts and components shares in exports. In addition to ASEAN countries, we include other East Asian countries, selected Central and Eastern European countries, Costa Rica, Mexico, and the average figures for the Union of South American Nations member countries, as a reference.[5]

In both years of interest, 2007 and 2013, Malaysia, the Philippines, and Singapore all had strikingly high percentages of machinery parts and components, reaching almost 40 percent or even higher, not only in total manufacturing exports but also in imports. Such high percentages of machinery parts and components, both for the export and import sides, appear to reflect these countries' active participation in back-and-forth transactions of intermediate goods across borders within machinery production networks. In contrast, for Costa Rica, the percentages of machinery parts and components reached 70–85 percent for the export side, whereas the corresponding percentages were below 30 percent for the import side.

Thailand is also highly dependent on the machinery trade, but shows a different trend: In 2013, for example, the percentage of machinery parts and components was below 25 percent for the export side, whereas the corresponding percentage reached almost 30 percent for the import side. At the same time, the percentage of machinery final products in exports was relatively high, compared with parts and components, exceeding 35 percent. Such a pattern of dependence on the machinery trade is also observed for China, Mexico, and Slovakia, and can be considered as indicating these countries' role as the world's factory in machinery production networks, in the sense that they import a large number of intermediate goods for assembly or for manufacturing products to be exported back to the countries of origin, or to the rest of the world.

Vietnam, Cambodia, and Lao PDR experienced noticeable increases in the relative importance of the machinery trade in the period 2007–13. For Vietnam, the percentage of machinery final products in exports more than tripled, from 10 percent to 35 percent, and the percentage of machinery parts and components in imports almost doubled, from 18 percent to 33 percent.[6] As of 2013, the shape of Vietnam's stacked bars resembles those for China, Mexico, Slovakia, and Thailand, suggesting that Vietnam now performs a similar role to those four countries, as the world's factory.

5 The Union of South American Nations includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela.

6 The increasing importance of machinery final products in Vietnam's exports is due largely to increases in exports of printers by Canon, communication devices by Samsung Electronics, and others.

Although Cambodia and Lao PDR, as well as Myanmar, seem still to be far behind other countries in the sample in terms of their machinery parts and components shares in exports and imports, they are increasingly dependent on the machinery trade. For Cambodia, the machinery share in exports quadrupled, driven by a surge in machinery parts and components exports in the period 2007–13, although it remained below 10 percent. For Lao PDR, the percentage of machinery parts and components in imports doubled, from 13 percent to 27 percent, although the overall machinery share for the export side remained negligible over the period. These countries reflect the so-called "Thailand plus one" operation between a mother factory in Thailand and a satellite factory in Cambodia or Lao PDR.

3. Diversification of export products and destinations

A key aspect of increased involvement in international production networks is the formation of trade links for a wider range of products with a wider range of trading partners. In what follows, departing from simply looking at the value of trade, we turn our attention to the diversity of exported products and destination market countries in quantifying the magnitude of trade occurring within production networks. In so doing, we admit that we miss other important aspects of increased involvement in these networks, such as the volume of exports through newly formed links relative to long-standing ones. Nevertheless, we confine the paper's scope to the diversification of exported products and destination countries because the formation of trade links is of first-order importance, especially for the less-developed ASEAN countries included in our analysis.

From the perspective of the diversification of exported products and destination countries, the rest of the paper is devoted exclusively to a detailed examination of exports of machinery parts and components. Although trade within production networks includes exports of finished products made from imported inputs as well, we leave an analysis of exports of machinery finished products in relation to imports of machinery parts and components to future research.

Focusing on exports of machinery parts and components, we count the number of products traded and the number of trading partners across products, and analyze patterns of export product and destination diversification. Specifically, we study: (i) how many products a country exports to how many destination market countries; (ii) how many of potential export flows (i.e., product-destination pairs) a country is actually involved in; (iii) how a country's export product diversification varies across destination countries; (iv) how a product–destination mix in a country's exports changes over time; and (v) what factors are correlated with the export product and destination diversification.

The number of products classified under machinery parts and components at the six-digit level of the HS 1996 classification is 445, and our data set includes 139 countries. We are

interested in how many products, out of the maximum possible number of 445, a country exports to how many destination countries, out of the maximum number of 138.[7]

In addition to merely counting the numbers of products exported and destination countries, we examine how many potential export flows a country is actually involved in. Following Baldwin and Harrigan (2011), we define a zero as a country's export flow (i.e., a product–destination pair) that could have occurred but did not. Naturally, on the other hand, actually occurring export flows are referred to as non-zeros. That is, a zero occurs when a country exports a certain product at the HS six-digit level to at least one country but not to all countries. By so doing, zero export flows consist only of goods actually produced in the country of origin. Furthermore, in identifying a zero export flow, we restrict attention to destination countries to which the country of interest exports at least one product classified under machinery parts and components. In other words, we exclude exporter–importer pairs with no trade in machinery parts and components at all from our analyses in this and the following sections.

3.1 Number of export products and destinations

Table 1 provides an initial overview of exports of machinery parts and components to the world, by country. The values of exports in 2007 and 2013, and the growth rates of export values between the two years, are reported on the left part of the table. The numbers of products exported, the numbers of destination market countries, the numbers of non-zero product-destination pairs, and the proportions of non-zero to potential product-destination pairs in 2007 and 2013, are shown on the right part of the table. The figures for ASEAN countries are compared with other East Asian countries.

First and foremost, non-zero export flows occurred only in a limited portion of potential product–destination pairs of ASEAN countries' machinery parts and components exports, even at the HS six-digit level.[8] The percentages of non-zero product–destination pairs ranged from 3.6 percent (calculated for Myanmar) to 31.6 percent (Thailand) in 2013, indicating that zeros made up more than the two-thirds of potential export flows (even for Thailand), and was more than 96 percent for Myanmar. The predominance of zeros was

7 In the literature on the extensive and intensive margins of trade, there are discussions over whether to use a fixed cutoff of US$ 0 or alternative cutoffs varying across countries as a measure of traded-ness—that is, whether a product is traded or not in a particular period (Kehoe and Ruhl 2013). As the current paper does not examine margins of trade growth but focuses on counting the number of products traded and the number of trading partners, we simply use a cutoff of US$ 0.

8 The predominance of zeros at the HS six-digit level understates the number of zeros at the firm level because each HS six-digit code possibly contains products of different firms that might export only to a subset of the overall destination mix of the HS six-digit code.

Table 1. Number of products and destinations in machinery parts and components exports to the world

Exporter country	Export value (millions US $) 2007	2013	Growth, %	N. of products 2007	2013	N. of destinations 2007	2013	N. of non-zero product-destination pairs 2007	2013	Shares of non-zero pairs, % 2007	2013
ASEAN member countries											
Malaysia	72,585	86,462	19.1	439	430	133	132	14,802	16,836	25.4	29.7
Singapore	46,939	43,918	−6.4	442	435	134	136	17,272	17,875	29.2	30.2
Thailand	34,986	38,764	10.8	439	428	134	135	16,036	18,243	27.3	31.6
Philippines	43,025	30,266	−29.7	421	408	121	129	7,715	9,404	15.1	17.9
Vietnam	3,361	14,715	337.8	399	402	113	126	4,638	8,461	10.3	16.7
Indonesia	13,295	12,405	−6.7	434	422	134	136	10,129	12,185	17.4	21.2
Cambodia	4	206	4,981.5	157	214	58	71	297	582	3.3	3.8
Myanmar	31	52	66.1	118	181	41	55	203	359	4.2	3.6
Lao PDR	10	33	221.3	124	139	37	42	181	256	3.9	4.4
Brunei	7	26	253.2	151	184	42	46	268	427	4.2	5.0
Northeast Asian countries											
China	228,266	344,601	51.0	445	439	136	138	38,623	43,410	63.8	71.7
Japan	241,098	229,652	−4.7	444	437	137	138	31,913	31,141	52.5	51.6
Korea	140,333	193,299	37.7	438	431	133	137	23,746	25,342	40.8	42.9
Other East Asian countries											
India	10,565	16,540	56.6	441	434	135	137	21,231	25,129	35.7	42.3
Australia	5,219	4,820	−7.6	436	427	132	135	15,291	15,934	26.6	27.6
NZ	1,078	1,017	−5.7	419	412	125	128	6,647	7,569	12.7	14.4

Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level), IMF IFS database (US CPI).*

Note: *We basically use import statistics to construct a dataset for bilateral trade flows at the HS six-digit level, consisting of 139 countries, with a few exceptions. Machinery industries are defined as HS 84-92, and among them we identify parts and components, following Kimura and Obashi (2010). Countries are listed in descending order of the total value of machinery parts and components exports to the world in 2013, by the country group. Export values are deflated by the consumer price index (CPI) in the US to obtain a constant dollar series, and are rounded off to the million. All figures expressed in percentage terms are rounded off to the tenth. In our dataset, the maximum possible number of products is 445 and that of destinations is 138. See the text for more details on the dataset construction.*

also common among other East Asian countries, with the exception of China, for which the incidence of zeros was surprisingly low, at 28 percent.[9]

Overall, the number of products exported, as well as the number of destination countries, varied less from country to country than the value of exports. First, Brunei, Cambodia, Lao PDR, and Myanmar are relatively far behind other countries in terms of export values, but are much closer in terms of both the number of products and the number of

9 The predominance of zeros is not special to ASEAN countries' machinery parts and components export flows. For example, Haveman and Hummels (2004) found that 27 percent of bilateral import flows (that contain products exported by at least one country in the world) were zeros at the SITC four-digit level in 1990. Baldwin and Harrigan (2011) document that 82 percent and 93 percent of the United States' potential export and import flows are zeros, respectively, at the HS ten-digit level in 2005. In Baldwin and Harrigan's method, a zero occurs when a country exports (imports) a product to (from) at least one country but not all. At the aggregate country level, instead of the country-product level, Helpman, Melitz, and Rubinstein (2008) found that about half of the country pairs in their sample covering 158 countries did not trade with each other in the period 1970–97.

destinations. Second, Malaysia, Singapore, and Thailand have not reached the same level of export values as Northeast Asian countries, but their exports were almost as diverse as those countries' exports, in terms of both the number of products and the number of destinations, as of 2013. As indicated by the percentages of non-zero product–destination pairs, however, Malaysia, Singapore, and Thailand still had a far less dense product–destination mix than Northeast Asian countries.

For Indonesia, Malaysia, the Philippines, and Thailand (ASEAN-4), together with Singapore, the number of exported products appears to have already hit a ceiling, showing a decline in the period 2007–13. Meanwhile, the number of destination countries trended upwards with the exception of Malaysia, which experienced a slight decrease. In addition, reflecting the fact that the number of non-zero product–destination pairs increased substantially during the period, these countries, even Malaysia, experienced a rise in the percentage of non-zeros, indicating that their product–destination mix had become denser, as well as more geographically diverse. Similar trends were also observed for China, the Republic of Korea, India, Australia, and New Zealand.

Malaysia and Thailand steadily increased their value of exports, although at a less rapid rate than China, India, and the Republic of Korea, in the period 2007–13. Indonesia, the Philippines, and Singapore, on the other hand, experienced negative growth in their export values. Nevertheless, for the latter group of countries, the export product–destination mix became more geographically diverse and denser, as discussed earlier. For the Philippines, in particular, the number of destinations noticeably increased despite the decrease of 30 percent in export value. This suggests that the Philippines underwent a dramatic transformation of its product composition from a heavy dependence on narrowly scoped semiconductor operations to wider-based electric and electronic industries.

Cambodia, Lao PDR, Myanmar, and Vietnam (CLMV), together with Brunei, have started exporting more products to more destination countries, while strikingly increasing the value of exports, over the period 2007–13. The most notable is Cambodia: Although its product–destination mix remained less diverse than forerunner ASEAN countries, the number of products and the number of destinations increased by 22 percent and 36 percent, respectively, and its export value increased by a factor of 51 times.

Vietnam showed a remarkable performance among the CLMV, not only in terms of the value of its exports, which exceeded even the level of Indonesia in 2013, but also in terms of the number of exported products and destination countries, and the percentage of non-zero product-destination pairs. Although Vietnam's machinery parts and components exports seem relatively insignificant in its total manufacturing exports to the world (Figure 1), it has diversified and increased the density of its product-destination mix, reaching almost the same level as the Philippines in 2013.

3.2 Distribution of the number of export destinations across products

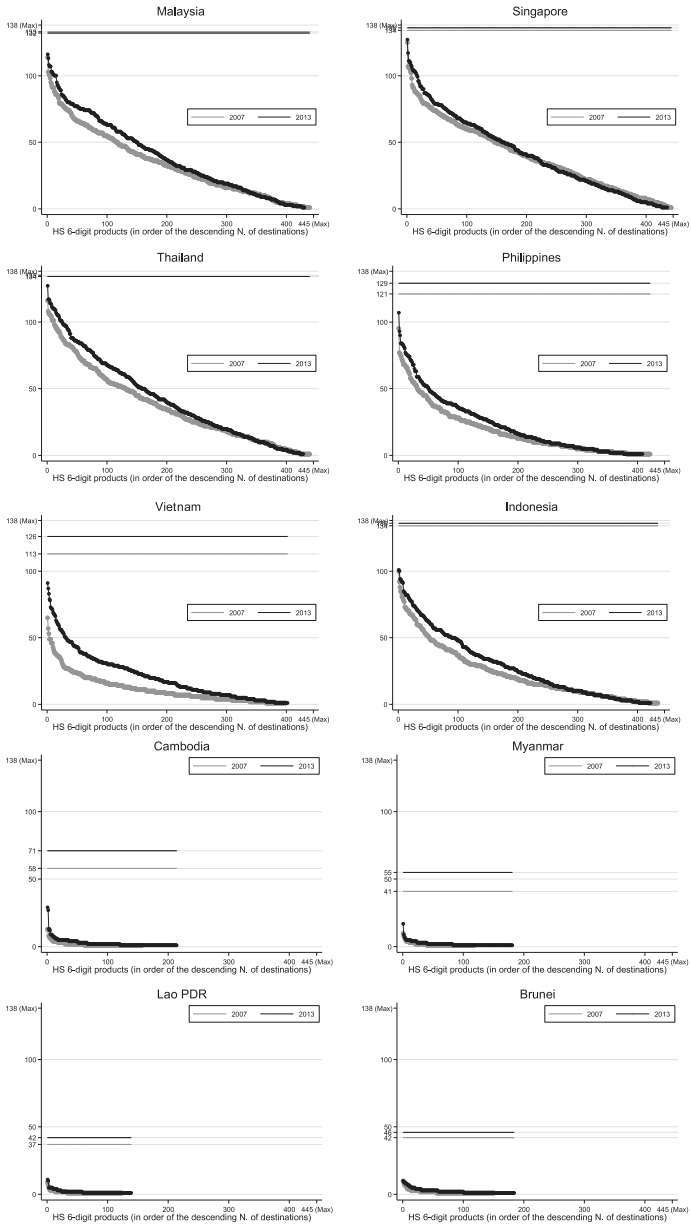
Figure 2 illustrates how the number of destination market countries in ASEAN countries' machinery parts and components exports to the world are distributed across products, comparing 2007 and 2013. On the horizontal axis, products at the HS six-digit level are placed in descending order in terms of the number of destination countries for each year. The horizontal axis ends with 445, the maximum possible number of products classified under machinery parts and components. The vertical axis indicates the number of destinations out of the maximum number of 138. The horizontal reference line represents a country's overall number of destination countries (Table 1). The area that lies below the reference line and the scatter plot line corresponds to the number of potential and non-zero product–destination pairs, respectively. Note that the vertical difference of the two scatter plot lines does not necessarily indicate a change in the number of destinations for a particular product, as the order of products differs by year. Instead, comparing scatter plot lines across years reveals how much the number of destinations changes on average across products.

For respective ASEAN countries, only a limited number of products are exported simultaneously to a substantial portion of the country's overall number of destination countries. Even for Thailand, which achieved the largest number of non-zero export product–destination pairs among ASEAN countries in 2013, only 24 percent of its exported products were shipped to more than half of the overall number of destinations (which was 135 out of 138, as in Table 1). The corresponding figures for the rest of the ASEAN-4, Singapore and Vietnam, were even smaller, ranging from 3 percent (Vietnam) to 20 percent (Malaysia). Moreover, for Brunei and the rest of CLMV, no single product was shipped simultaneously to half of the country's overall number of destinations, and about half of the country's exported products were shipped to only one country. These observations illustrate the incidence of zeros in ASEAN's potential export flows.

Thailand and Singapore serve a remarkably wide range of countries at the product level, compared with other ASEAN countries. In 2013, Thailand's top four exported products, in terms of the number of destinations, were shipped to more than 115 countries, and Singapore's top four products were exported to more than 110 countries.[10] In addition, these countries' export product–destination mix was notably dense with their neighboring countries in the East Asian region: Thailand and Singapore exported 46 and 44 products, accounting for 11 percent and 10 percent of the maximum possible number, simultaneously to all of the 15 (= 16 − 1) East Asian trade partners, respectively (see Appendix Figure A.1 for the intra-East Asian version of Figure 2).

10 All of Thailand's top four exported products are parts and components and accessories used for motor vehicles. Singapore's top four products are parts and accessories of data processing equipment, parts of line telephone and telegraph equipment, and electrical switches.

Figure 2. Number of destinations in machinery parts and components exports to the world, distribution across products



Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level).*

Note: *See notes of Table 1. Countries are arranged in descending order of the total value of machinery parts and components exports to the world in 2013.*

Although zero export flows were still predominant among ASEAN members, all countries widened their geographic scope of export destinations on average across products in the period 2007–13, in addition to increasing the overall number of destination countries (except Malaysia, as reported in Table 1). Most notably, Vietnam doubled the number of destinations at the product level from 11.6 to 21 on average. The largest number of destinations at the product level increased from 65 to 91 and, as of 2013, 14 products were exported to more than 65 countries. Also noteworthy was that the ASEAN-4, at the forefront of export product and destination diversification, further increased the number of destinations at the product-level from 5 to 6 on average.

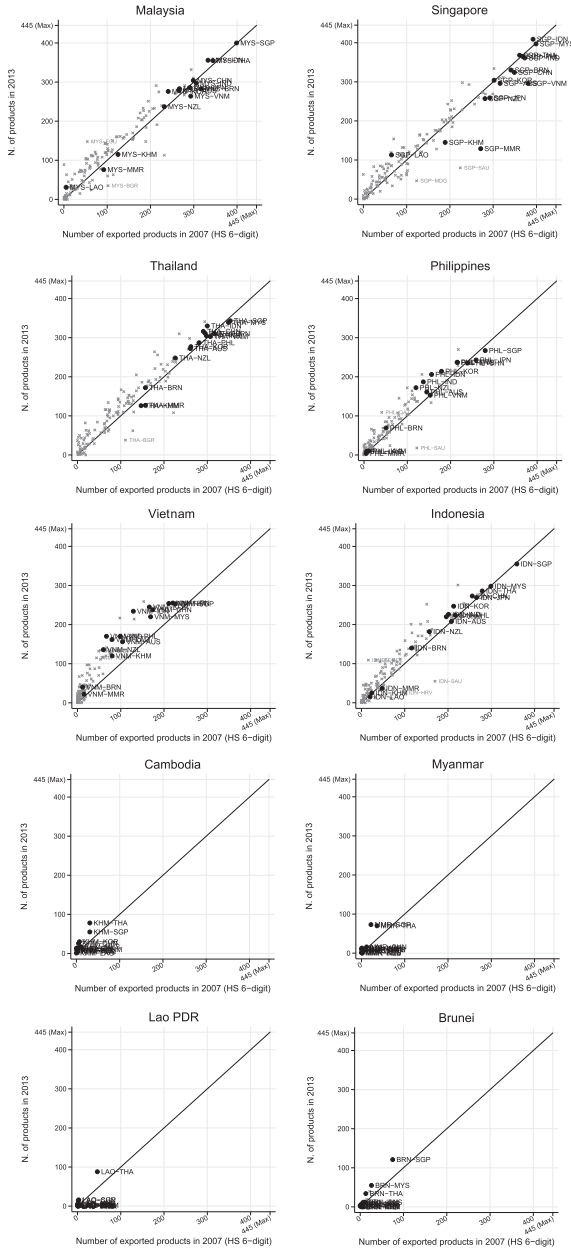
3.3 Number of export products by destination

Looking at another aspect of the diversification of ASEAN countries' machinery parts and components exports, Figure 3 illustrates how the number of products exported from a country varies across destination market countries. The horizontal axis indicates the number of products exported at the HS six-digit level in 2007, ending with the maximum possible number of 445, and the vertical axis represents the number of products in 2013. Dots show the numbers of products exported to each of East Asian trade partners and are labelled with the ISO 3166–1 country codes for the exporter–importer pairs. Gray cross-marks represent export flows to countries outside the East Asian region, with a few outliers, and are labelled with the exporter–importer pair country codes. For reference, the 45-degree line is shown to help the reader to see if the number of products exported to a particular country increased or decreased in the period 2007–13.

Overall, the numbers of products exported to East Asian trade partners tended to be far higher than those for destination countries outside the region. In 2013, the average number of products in intra-East Asian exports was 2.3 (Thailand) to 6.4 (Myanmar) times as large as the average number for exports to countries outside the region. In particular, the numbers of products exported to Singapore or Thailand were notably large. Meanwhile, Singapore and Thailand exported more than 110 products, or more than one-fourth of the maximum possible number, to each of the East Asian trade partners, on top of the fact that they exported about 45 products simultaneously to all the East Asian partners (as discussed in Section 3.2). Singapore and Thailand appear to have established complicated back-and-forth trade links for a wide range of machinery parts and components inside the region. In addition, the number of products exported to Japan was one of the largest among Vietnam and the Philippines' export flows.

For most ASEAN countries, the number of products exported to the landlocked country of Lao PDR was limited. Malaysia, for example, exported a mere 31 products to Lao PDR in 2013, whereas its second-smallest number of products exported bilaterally within East Asia was 76 (which was a record for Malaysia's exports to Myanmar). In contrast, Thailand, which shares a common border with Lao PDR, already exported about 300 products

Figure 3. Number of products in machinery parts and components exports, by destination country



Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level).*

Note: *See notes of Table 1. Countries are arranged in descending order of the total value of machinery parts and components exports to the world in 2013.*

to Lao PDR as of 2007, and widened the range of products to 311 in 2013, which was the sixth largest, following Singapore, Germany, Malaysia, Indonesia, and China, among Thailand's total export flows. For Vietnam, another country sharing a border with Lao PDR, the number of products exported to Lao PDR almost doubled to over 160 products in 2013, which was nearly close enough to reach the level of Vietnam's exports to India or the Philippines. The number of products exported to Cambodia or Myanmar also tended to be limited for almost all the ASEAN countries, but one of the noticeable exceptions was Vietnam's exports to Cambodia, with the two countries sharing a border. These observations imply a positive correlation between the extent of (destination-specific) export product diversification and the country of origin's geographical proximity to a destination market.

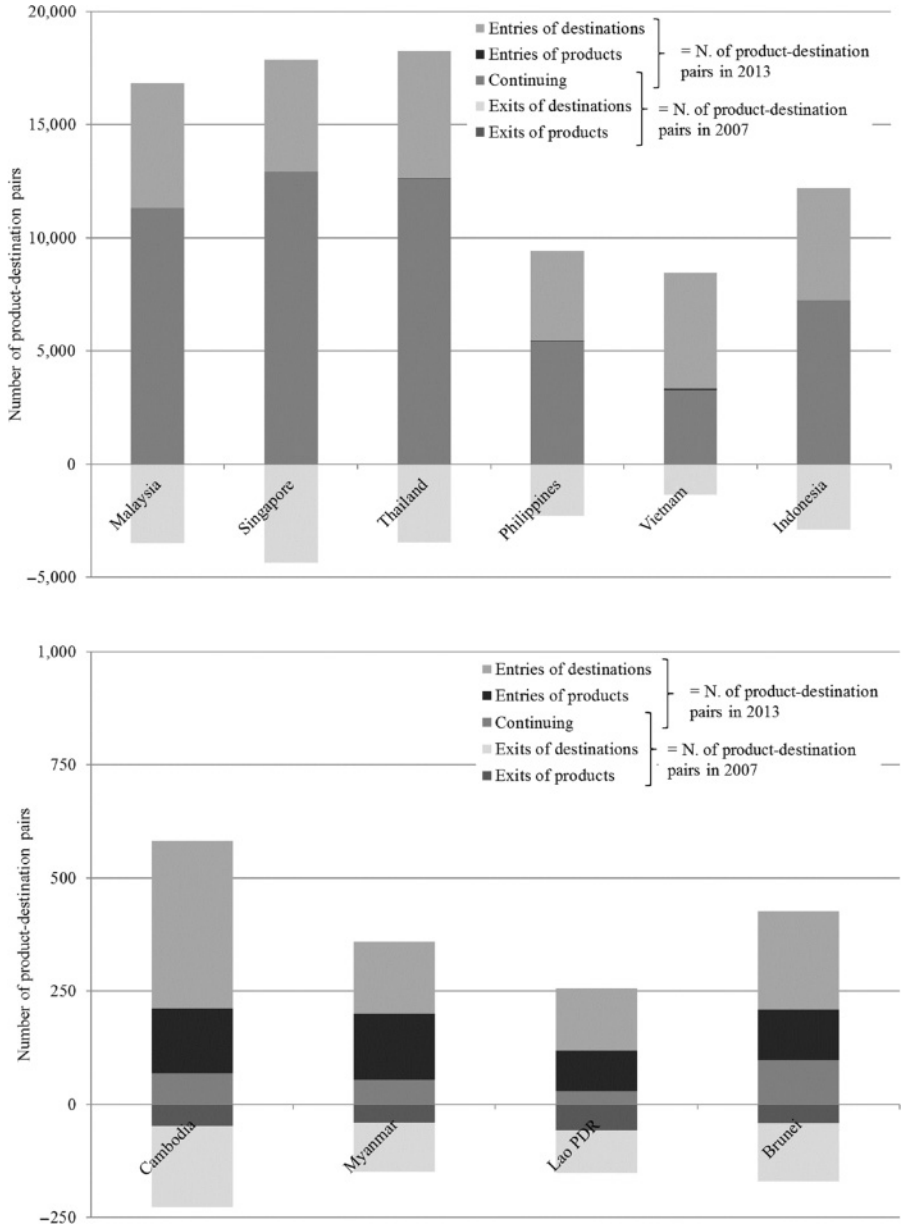
Another point to note is that Brunei, Cambodia, Lao PDR, and Myanmar have almost no trade in machinery parts and components with one another. As of 2013, two-thirds of exporter–importer pairs of these less-developed ASEAN countries actually had no transactions of machinery parts or components at all. It appears that, despite the networking of back-and-forth trade links of machinery parts and components within East Asia centering on Singapore and Thailand, machinery production fragmentation has not yet occurred among the less developed ASEAN countries.

3.4 Number of export product–destination pairs: Ins and outs

Next, looking at changes in the number of (non-zero) product–destination pairs in a country's exports, Figure 4 reveals that a substantial amount of ins and outs of product–destination pairs are going on beneath the surface. A country experiences a change in the number of product–destination pairs (i.e., on the extensive margin) by exporting a new product that has never been exported before, or by exporting an already-exported product to a new destination country to which the country had not previously provided that product.[11] Ins of product–destination pairs occur through entries of products to a country's export product mix, or through entries of destinations to a country's product-specific destination mix. Similarly, outs of product–destination pairs occur through exits of products, or through exits of destinations. The stacked bars in Figure 4 show the composition of changes in the number of product–estination pairs by comparing a country's export pattern between 2007 and 2013. The number of product–destination pairs in the initial year of 2007 equals the sum of continuing pairs and outs of pairs attributing to exits of products or destinations, while the number of pairs in the latter year of 2013 equals the sum of continuing pairs and ins due to entries of products or destinations.

11 To the best of our knowledge, Besedeš and Prusa (2011) is one of few previous studies that examine changes in a country's exports to the world by decomposing the extensive margin into the new product margin and the new destination margin. We follow Besedeš and Prusa's way of thinking of the extensive margin. Other studies, such as Kehoe and Ruhl (2013), focus only on the new product margin because they examine changes in trade patterns for a selected country pair.

Figure 4. Number of product-destination pairs in machinery parts and components exports to the world



Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level).*

Note: *See notes of Table 1. Countries are arranged in descending order of the total value of machinery parts and components exports to the world in 2013.*

All the ASEAN countries increased the number of pairs by between 3 percent (Singapore) and 96 percent (Cambodia) for the period 2007–13. Meanwhile, all countries experienced a substantial amount of ins and outs of product–destination pairs. The relative importance of ins and outs, as a percentage of the number of continuing pairs, tends to be larger for a country with a smaller number of pairs in total. Even for Singapore and Thailand, whose product–destination mix is outstandingly diverse among the ASEAN countries, ins and outs of product–destination pairs reached the level of 40 percent and 30 percent of the number of continuing pairs, respectively. For Lao PDR, whose product–destination mix was the least diverse, ins and outs of product–destination pairs were eight and five times as large as the number of continuing pairs, respectively.

Not only for Singapore and the ASEAN-4, whose export product mix appears to have already hit a ceiling (Table 1), but even for countries lagging in export product diversification, entries and exits of destinations tended to occur to a greater extent, compared with entries and exits of products. In addition, there were a considerable number of exits, as well as entries, of export destinations, suggesting that countries have undergone a non-negligible downsizing of the (product-specific) destination mix for some products, while diversifying the destination mix for other products, during a period of only six years. A remarkable exception was Myanmar, for which the overall number of exported products, as well as the overall number of destinations, increased by 30 to 50 percent in the period 2007–13 (Table 1), and ins of product–destination pairs were equally attributed to entries of products and to entries of destinations.

4. Probability of exporting a product to a particular market

The preceding section highlighted that networks of back-and-forth trade links of machinery parts and components have developed, notably inside the East Asian region, centering on Singapore and Thailand. In addition to Singapore, Thailand, and the other ASEAN-4 countries, Vietnam is an increasingly active player in the formation of global, as well as regional, production networks in the machinery industry. Vietnam's machinery parts and components exports seem relatively insignificant in its total manufacturing exports, but are remarkably diversified in terms of both a wider range of exported products and destination market countries. In sharp contrast to Vietnam, the rest of the CLMV and Brunei lag far behind other ASEAN countries in terms of export product and destination diversification, as well as in terms of the value of machinery parts and components exports, although there are signs of catching up. These less-developed ASEAN countries were only involved in machinery production networks to a limited extent. Moreover, machinery parts and components trade was not observed at all between the less developed ASEAN countries.

To help us understand the observed patterns of ASEAN countries' involvement in international production networks in the machinery industry, this section offers a statistical analysis of the probability that a product at the HS six-digit level is exported from a particular country of origin to a particular destination country. In line with Baldwin and Harrigan (2011), we document a reduced-form relationship between the probability of a non-zero export flow and its explanatory variables for ASEAN countries' machinery parts and components exports in 2013. Applying gravity logic to the incidence of zeros in terms of global production sharing suggests that a non-zero export flow is more likely the less costly the transport of the good from the country of origin to the destination market country, the lower the service link costs to coordinate geographically separated production stages across borders, the larger the production of the good in the country of origin, the larger the demand for the good in the destination, and the larger the differences in location advantages, such as wages, between the countries.

4.1 Variables and data

To measure the factors affecting the probability of exporting, we include the following variables: as proxy for international transportation costs, telecommunication costs, and other costs related to geographical distance, we use bilateral distance (km) between the country of origin and destination countries, and country pair–specific dummies indicating contiguity and the common official language. Distance would affect the incidence of zero and non-zero trade flows within production networks more than in other forms of transactions, because intermediate goods and semi-finished products cross borders multiple times through the global value chain. In addition, the service link costs, although dependent on a country's trade and investment-related policies as well, would depend on distance to a considerable extent. Data on distance and associated indicator variables are obtained from the GeoDist database of the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).

As a proxy for the size of production and demand for a product at the HS six-digit level, we include the GDP of both the country of origin and the destination country instead of more immediately relevant industry-level input-output data. As an economy grows, industrial production becomes larger in scale and diversified enough to be able to take part in global production sharing and to be attractive to foreign investors, possibly leading to the emergence of non-zero trade flows. Data on GDPs (in current U.S. dollars) come from the World Bank's World Development Indicators (WDI) database.

In addition to these variables that have been traditionally used in the gravity literature, we control for the differences in location advantages that provide a basis for a shift of production activities from one country to another through cross-border fragmentation of production, which is accompanied by a newly formed trade link between the countries. The international wage differentials are considered an important element

of location advantages. We use GDP per capita as a proxy for wages and introduce the absolute value of the difference in GDP per capita between the country of origin and the destination country.

We also consider, for both the country of origin and the destination country, the trade- and investment-related policies that reduce the service link costs by introducing the World Bank's Logistics Performance Index (LPI). Although technological advancement in information and communication technology and transportation technology all over the world has improved the timeliness and efficiency of coordination between geographically disperse production stages, a country's competence and the quality of trade logistics services and infrastructure make a difference in the attractiveness as an investment destination for networking firms and the global competitiveness to participate in production networks.

Non-zero export flows are more likely when a pair of countries belongs to a common regional trade agreement (RTA), because the formation of an RTA not only reduces transportation costs by lowering tariffs but also facilitates cross-border transactions in a broader sense. We include a country pair–specific dummy indicating that an RTA is in force, as of 1 January 2013. ASEAN countries are now linked not only with other ASEAN countries but also with all the East Asian partners by RTAs. In addition, as of 1 January 2013, Brunei, Lao PDR, Malaysia, and Singapore have formed RTAs with non-East Asian countries. Information on RTAs notified to the World Trade Organization (WTO) is available in the WTO's Regional Trade Agreements Information System (RTA-IS) database.

As illustrated by Figure 4, all ASEAN countries with the exception of Myanmar have undergone diversification of export flows to a greater extent by exporting an already-exported product to a new destination country, to which the country had not previously provided that product. This observation suggests that the country of origin's global experience in exporting the product has a considerable positive effect on the probability of exporting in a later year. We therefore include an origin-product pair-specific dummy indicating the country of origin's previous experience in exporting the product. This global-export-experience dummy takes a value of 1 if the country exported the product at the HS six-digit level to at least one country in the world in the initial year of 2007.

Lastly, as illustrated by Figure 3 and Appendix Figure A.1, ASEAN countries tend to export a wider range of products to East Asian trade partners than to destination countries outside the region, and consequently have developed networks of back-and-forth trade links most notably with East Asian partners. These observations suggest that there may be an additional premium for intra-East Asian trade even after controlling for the previously discussed factors. In order to capture any possible fundamental difference between intra-East Asian exports and exports to countries outside the region, we introduce

destination-specific intercept and slope dummies indicating intra-East Asian trade, which equals 1 if the destination, as well as the origin ASEAN country, are in the East Asian region. Note that, because ASEAN countries have RTAs in force with all the East Asian countries, the interaction term between the RTA dummy and the intra-East Asia slope dummy is subsumed into the intra-East Asia intercept dummy. In other words, what the intra-East Asia intercept dummy actually captures contains the effect of the RTA formation.

4.2 Results

We estimate two different versions of specification, with and without the intra-East Asia intercept and slope dummies, using logistic regression. The dependent variable is a binary indicator for a non-zero export flow in a particular HS six-digit code of machinery parts and components from a particular origin country of ASEAN to a particular destination market in 2013, conditional on being exported from the country of origin to at least one other country in the world from 139 countries in our data set. Our sample includes respective ASEAN countries' potential export flows (i.e., product-destination pairs) for which full data on explanatory variables are available. All continuous variables are log transformed.

The results are shown in Table 2. For each specification, we report the estimated coefficients in log-odds units—that is, on the log odds ratios of the probability of exporting, for respective explanatory variables including interaction terms, and the average marginal effects of the independent variables on the predicted probability of exporting. Standard errors are robust and are clustered on exporter–importer pairs, allowing an arbitrary correlation in errors within a cluster but assuming independence across clusters.

The first pair of columns in Table 2 reports our baseline results for a specification without the intra-East Asia dummy. In the case of binary explanatory variables, an average marginal effect measures how the predicted probability of exporting changes on average across observations as the binary explanatory variable of interest changes from 0 to 1, holding all other variables as given. For example, the global-export-experience dummy has a strong positive marginal effect on the export probability: On average, the products that the country of origin has experience in exporting to at least one country in the world in the initial year are 18.8 percentage points more likely to be exported in a later year.

Likewise, the average marginal effect for continuous variables measures the instantaneous rate of change in the probability of exporting, but the interpretation is not that straightforward because the estimated marginal effect depends on how the independent variable is scaled. In the case of continuous variables, we limit our attention to checking the signs and significance of the marginal effects and comparing the magnitude of the marginal effects between independent variables on the same scale.

Table 2. Statistical determinants of ASEAN's non-zero export flows of machinery parts and components, 2013, logit estimation

	(1)		(2)	
	Coef	dy/dx	Coef	dy/dx
Log distance	−0.540***	−0.079***	−0.451***	−0.072***
	(0.067)	(0.010)	(0.100)	(0.013)
* *Intra-East Asia dummy*			−0.238	
			(0.159)	
Contiguity dummy	0.41	0.064	0.247	0.038
	(0.219)	(0.036)	(0.210)	(0.033)
Common-language dummy	0.124	0.019	0.016	0.008
	(0.094)	(0.014)	(0.117)	(0.015)
* *Intra-East Asia dummy*			0.227	
			(0.202)	
Log origin country's GDP	0.469***	0.069***	0.464***	0.068***
	(0.031)	(0.005)	(0.030)	(0.004)
Log destination country's GDP	0.367***	0.054***	0.388***	0.053***
	(0.019)	(0.003)	(0.021)	(0.003)
* *Intra-East Asia dummy*			−0.170**	
			(0.058)	
Log abs. diff. in GDP per capita	−0.053*	−0.008*	−0.065**	−0.009**
	(0.022)	(0.003)	(0.024)	(0.003)
* *Intra-East Asia dummy*			0.021	
			(0.045)	
Log origin's logistics performance	3.000***	0.441***	3.125***	0.457***
	(0.214)	(0.031)	(0.220)	(0.032)
Log destination's logistics performance	1.755***	0.258***	1.498***	0.280***
	(0.214)	(0.031)	(0.221)	(0.031)
* *Intra-East Asia dummy*			2.479***	
			(0.602)	
RTA dummy	0.058	0.009	−0.168	−0.024
	(0.100)	(0.015)	(0.129)	(0.018)
Global-export-experience dummy	1.889***	0.188***	1.885***	0.187***
	(0.130)	(0.008)	(0.124)	(0.007)
Intra-East Asia dummy			3.688*	0.028
			(1.463)	(0.033)
Number of observations	322,477 (origin-destination-product combinations)			
Pseudo R^2 (McFadden)	0.187		0.189	
Wald χ^2 statistics	1,946		2,205	
Prob. > Wald χ^2 statistics	0.000		0.000	

Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level), CEPII GeoDist database (distance and geographical indicators), WB WDI (GDP) and LPI database (Logistics Performance Index), WTO RTA-IS database (RTA dummy).*

Note: *Dependent variable is a binary indicator for a non-zero export flow in a particular HS six-digit code from a particular origin country to a particular destination market country. Machinery industries are defined as HS 84-92, and among them we identify parts and components, following Kimura and Obashi (2010). Brunei is not included in the estimation reported above because the data for the Logistics Performance Index are not available. Reported results are the estimated coefficients (in log-odds units) and the average marginal effects on the predicted probability of exporting. The estimates for the constant term are not reported but are included in the regressions. Standard errors are clustered on exporter-importer pair. Asterisks denote statistical significance: *** significant at the 0.1 percent level; ** significant at the 1 percent level; * significant at the 5 percent level.*

In our baseline results, most of the explanatory variables have statistically significant average marginal effects on the probability of exporting as expected, but with two exceptions: First, the absolute value of the difference in GDP per capita has a negative and significant marginal effect on the export probability, as opposed to the expectation that

non-zero export flows of machinery parts and components are more likely when differences in location advantages between the pair of countries are large. On one hand, we need to account for other crucial elements of location advantages beyond the international wage differentials for further analysis. On the other hand, this result suggests that ASEAN countries do not export a wide range of machinery parts and components to high-income countries, but rather have developed export links of machinery parts and components with destination countries at a similar level of economic development, including ASEAN countries themselves and other developing countries in the East Asian region. Second, the contiguity dummy, the common-language dummy, and the RTA dummy have a positive (as expected) but insignificant marginal effect on the export probability.

The second pair of columns in the table is for a specification that also includes the intra-East Asia intercept and slope dummies. By introducing the intra-East Asia dummy, the average marginal effects for the contiguity dummy and the common-language dummy become small in magnitude, although remaining insignificant, and the marginal effect for the RTA dummy turns negative but also remains insignificant.[12] For all the other explanatory variables, the marginal effects are similar to their baseline estimates in terms of sign and significance. The intra-East Asia dummy of interest has a positive, but insignificant, marginal effect on the probability of exporting. We do not detect any statistically significant premium for intra-East Asian exports, compared with exports to countries outside the region, on average across ASEAN countries' potential export flows, after controlling for differences in trade costs, production and demand size, location advantages, service link costs, and exporting experience.

In sum, the logit estimation results reported in Table 2 illustrate a clear relationship between the probability of exporting, and gravity and other variables for ASEAN countries' machinery parts and components exports: A non-zero export flow is more likely the lower the trade costs, the larger the production in the country of origin, the larger the demand in the destination country, the smaller the gap in GDP per capita between the origin and destination countries, and the lower the service link costs. In addition, the country of origin's global experience in exporting a particular product has a large positive effect on the export probability.

12 Debaere and Mostashari (2010) studied the impact of changing tariffs (at the product level) on the range of products exported and found that a mere 5–12 percent of the extensive margin of exports to the United States is explained by tariff cuts. In line with Debaere and Mostashari, we could look into each RTA to see if it actually lowers tariffs or contributes to facilitating cross-border transactions of machinery parts and components, although this is beyond the scope of this paper.

Table 3. Country-by-country comparison of marginal effects of selected explanatory variables

Variable	Log destination's GDP	Log abs. diff. in GDP per capita	Log destination's logistics performance	Global-export experience dummy	Intra-East Asia dummy
Malaysia	0.059***	−0.015	0.333***	0.298***	0.045
	(0.007)	(0.010)	(0.083)	(0.013)	(0.074)
Singapore	0.061***	0.005	0.236**	0.298***	−0.068
	(0.007)	(0.015)	(0.084)	(0.014)	(0.061)
Thailand	0.056***	−0.027**	0.425***	0.305***	0.235***
	(0.007)	(0.009)	(0.096)	(0.013)	(0.031)
Philippines	0.035***	−0.018	0.540***	0.179***	0.250***
	(0.006)	(0.009)	(0.089)	(0.009)	(0.063)
Vietnam	0.041***	−0.002	0.318**	0.166***	0.107**
	(0.005)	(0.008)	(0.099)	(0.006	(0.035)
Indonesia	0.050***	−0.020**	0.396***	0.213***	0.133
	(0.006)	(0.008)	(0.084)	(0.010)	(0.076)
Cambodia	0.012***	0.000	0.084	0.034***	−0.004
	(0.002)	(0.005)	(0.047)	(0.004)	(0.009)
Myanmar	−0.001	0.000	0.157*	0.019***	0.050**
	(0.004)	(0.004)	(0.062)	(0.004)	(0.018)
Lao PDR	0.008	0.000	0.100	0.016***	−0.012
	(0.005)	(0.005)	(0.089)	(0.004)	(0.019)
Brunei	0.001	−0.003	0.217***	0.029***	0.015
	(0.005)	(0.004)	(0.037)	(0.004)	(0.015)

Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level), CEPII GeoDist database (distance and geographical indicators), WB WDI (GDP) and LPI database (Logistics Performance Index), WTO RTA-IS database (RTA dummy).*

Note: *Reported results are from by-country logit estimation with the specification (2) in Table 2. See notes of Table 2. Brunei, as a destination country, is not included in the estimation reported above because the data for the Logistics Performance Index is not available. Asterisks denote statistical significance: *** significant at the 0.1 percent level; ** significant at the 1 percent level; * significant at the 5 percent level.*

4.3 Country-by-country comparison

We also conduct the same statistical analysis for each of the origin ASEAN countries, using the specification with the intra-East Asia dummy. The estimated average marginal effects for selected explanatory variables are compared between countries in Table 3. First, the global-export-experience dummy has a notably large and positive average marginal effect on the probability of exporting in the cases of Thailand, Malaysia, and Singapore, whose export product mix was already diverse enough to hit a ceiling in the initial year of 2007 (Table 1). The estimated marginal effects for the global-export-experience dummy are far smaller in the less-developed ASEAN countries, such as Lao PDR and Myanmar, reflecting the fact that a non-negligible amount of entries of products to the country's product-destination mix occurred in the period 2007–13 (Figure 4).

Second, the estimated average marginal effects for the destination country's GDP are relatively small in magnitude and statistically insignificant in the case of the less-developed ASEAN countries. The estimates for the destination country's Logistics Performance show a similar pattern, especially in Cambodia and Lao PDR. One possible explanation for these results is that a substantial portion of non-zero export flows from less-developed ASEAN countries is dictated by multinational firms' global operations and firms'

decisions on where to locate the fragmented production stages across borders, rather than simply driven by a larger size of GDP or a better quality of trade logistics and infrastructure in the (export) destination country. If this is the case, the (export) country of origin's attractiveness as an investment destination for multinational firms does matter for the export probability, and the export flow to a destination country where a mother factory is located does not depend on the destination country market's characteristics.[13]

Third, the absolute value of the difference in GDP per capita has a negative and significant average marginal effect on the probability of exporting in the cases of Thailand and Indonesia. Both countries were in the middle of the GDP per capita ranking among ASEAN countries, achieving a level close to the ASEAN average in 2013. Although further analysis on the effect of the differences in location advantages on the export probability is certainly needed, these countries appear to have developed and diversified export links of machinery parts and components, at least to some extent, with countries at a similar level of economic development, including their ASEAN neighbors, China and India.

Lastly, the estimated average marginal effects for the intra-East Asia dummy are positive and significant in the case of some countries. For example, Thailand, which is one of the most important players in regional production networks in East Asia, has on average a 23.5 percentage point greater probability of exporting a particular product to East Asian trade partners than comparable non-East Asian countries. The marginal effect for the intra-East Asia dummy is also relatively large and significant in Myanmar, unlike other less developed ASEAN countries. The latter result reflects Myanmar's strikingly high ratio of the average number of products in intra-East Asian exports to that in exports to countries outside the region (Figure 3).

In contrast to Thailand, the intra-East Asia dummy has no statistically significant average marginal effect on the probability of exporting in Malaysia and Singapore, both of which appear to be actively involved in global, as well as regional, machinery production networks. In addition, no premium for intra-East Asian trade is statistically detected for the less developed ASEAN countries with the exception of Myanmar, which reflects the fact that these countries have not yet been integrated into not only global, but even into regional, production networks.

5. Conclusion

This paper has assessed the degree of involvement of ASEAN countries in international production networks in the machinery industry, making use of product-level

13 Fung, Iizaka, and Siu (2010) empirically shows that foreign direct investment inflow positively affects the host country's exports of parts and components in East Asia.

international trade data. We have documented ASEAN's networking of back-and-forth trade links of machinery parts and components, notably with East Asian partners, centering on Singapore and Thailand. In addition to Singapore, Thailand, and other ASEAN-4 countries, Vietnam is an increasingly active player in such networks. Although the less-developed ASEAN countries have limited involvement in regional, as well as global, production networks, they are finally starting to join production networks in our sample period. Furthermore, we highlight that the probability of a non-zero flow in ASEAN countries' machinery parts and components exports is negatively correlated to trade costs and service link costs, and is positively correlated to production and demand size, and the country of origin's global experience in exporting a particular product, along with a premium for intra-East Asian trade in some countries.

The empirical investigation based on the product-level international trade data is proven to be effective in assessing the degree of participation in production networks. In particular, the initial stage of joining production networks is vividly traced by this approach. Deepening and widening of production networks along with the formation of domestic industrial agglomeration are also clearly illustrated. This does not complete the assessment of the whole industrialization process, however. The formation of industrial agglomeration, together with international production networks, is a novel phenomenon in the evolution of the new international division of labor with the second unbundling in ASEAN and East Asia. Industrial agglomeration in this region is motivated by the development of inter-firm (arm's length) transactions in proximity, rather than the one observed in Western Europe where economic activities with high transport costs are attracted by the most immobile element, people. Although both statistical data and the analytical approach are underdeveloped, the assessment of the functioning and consequences of industrial agglomeration has become increasingly important. We observe in a series of microeconomic surveys conducted by the Economic Research Institute for ASEAN and East Asia (ERIA) the occurrence of technology transfers and spill-over through transactions between foreign affiliates and local firms in industrial agglomeration, which encourages process/product innovation at the firm level and industrial upgrading at the aggregated level.[14] Our future research agenda should include the development of new empirical approaches for capturing the expansion of the scale and scope of industrial agglomeration by using international trade data.

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14 See, for example, Kimura, Machikita, and Ueki (2015).

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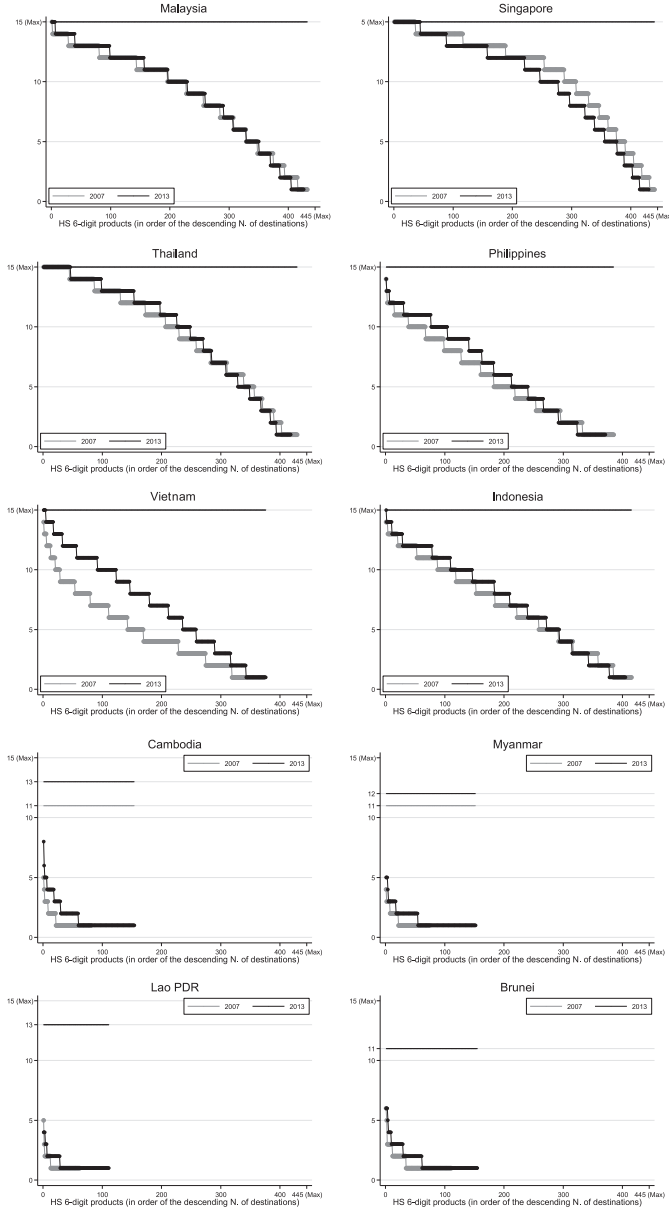
Appendix A: Intra-East Asian data

Figure A.1 Number of destinations in intra-East Asian machinery parts and components exports, distribution across products



Source: *UN Comtrade database (import statistics, based on the HS 1996 classification, at the six-digit level).*

Note: *This is the intra-East Asian trade version of Figure 2. See notes of Figure 2.*