Stability of Production Networks in East Asia: Duration and Survival of Trade*

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Abstract

This paper sheds light on the stability of international production networks in East Asia from the perspective of the duration and survival of bilateral trade relationships at the product-line level. Using highly disaggregated data for intra-East Asian machinery trade, survival analysis is conducted as well as the examinations of the duration and volatility of trade relationships. The product-level analyses reveal that machinery parts and components are traded through more stable and longer-lived relationships among East Asian countries, compared to final products. Once transactions are started, trade relationships of machinery parts and components are more likely to be maintained between countries even at a long distance, regardless of the exchange-rate fluctuations. Trade relationships of machinery final products, on the other hand, are more likely to be sensitive to the level of trading cost as well as the exchange-rate fluctuations.

Keywords: Duration of trade; survival analysis; fragmentation; East Asia

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1. Introduction

The development of international production and distribution networks in East Asia has stimulated a number of studies on its nature and characteristics as well as discussions on policy implications of its existence. While most of empirical works use aggregate international trade data, as a result, they overlook the underlying dynamics of trade. Among a number of interesting economic phenomena behind the aggregate trade value, this paper investigates the duration and survival of bilateral trade relationships at the product-line level so as to clarify the stability of production networks stretched across the region.

The production networks are formed by a firm's decision on whether or not to split up a previously integrated production process into two or more components and where to locate fragmented production blocks. Jones and Kierzkowski (1990), the seminal work on the fragmentation theory, suggested how integrated production processes could be characterized by a series of production blocks which are connected by service links such as transportation, communication and coordination.[1] Specifically, fragmentation becomes optimal when the costs of service links is low enough as well as when production cost per se is significantly reduced by taking advantage of differences in technologies and factor prices among locations. In terms of production networks in East Asia, considering its sophistication in the combination of intra-firm and arm's-length transactions, Kimura and Ando (2005) claim that the concept of fragmentation must be expanded to two dimensions including not only geographic distance but also the boundary of the firm. The idea of transaction costs emerging from disintegration of a firm has been long discussed in the industrial organization literature of vertical integration, and it has recently been incorporated into international trade models (See, for example, Grossman and Helpman, 2002, 2004, 2005).

The form of transactions of intermediate goods in international production networks established and controlled by corporate strategy of multinational enterprises has a

[1] For the fragmentation theory, see Arndt and Kierkowski (2001) and Deadorff (2001).

relation-specific nature, which is distinctly different from traditional transactions of only final products made entirely in one country. The costs of service links play a critical role in a firm's decision on whether or not to create the production networks with sunk costs to invest in fragmented production blocks. Moreover, each of the fragmented production blocks is often not be able to function effectively without coordination between upstream and downstream production processes. It would appear that once a trade relationship is established, the transaction of intermediate goods in international production networks is stable and long-lasting due to its relation-specific nature.

Since the beginning of the 1990s, East Asian countries have expanded and deepened intra-regional trade relationships, particularly in machinery parts and components trade. The intra East Asian export value of machinery parts and components rapidly increased 4.3 fold, while the overall intra-regional export value expanded by a factor of 2.6 in real terms from 1993 to 2006. The diversity of the East Asian region promotes opportunities for multinationals to locate fragmented production blocks in different locations with different location advantages all over the region. Although the formation of production networks has not been limited to the machinery sector, the machinery industry is by far the most important, both quantitatively and qualitatively, and extends the most sophisticated networks across East Asia and other regions (See Fukao et al. 2003; Athukorala and Yamashita 2006; Kimura 2006). In 2006, the share of machinery parts and components in the total merchandise exports from and imports to respective East Asian countries ranges from 8% to 57% and 12% to 50%, respectively. In the light of the explosive expansion of intra-regional machinery parts and components trade over the last couple of decades, this paper focuses on different trade patterns at the product-line level between machinery final products and parts and components so as to derive evidence for the stability of the networks.

This paper aims to shed new light on the stability of production networks in East Asia from the perspective of the duration and survival of trade relationships in intra-regional machinery trade. To this end, survival analysis is conducted, as well as the examinations of the duration and volatility of trade relationships. The country-product level data enables us to reveal how long a bilateral trade relationship at the product-line level is continued without interruption once the transaction is started and how the possibility of survival of trade relationships differs between machinery final products and parts and components.

The novel empirical approach highlights unexplored facts of international trade and confirms the difference in the possibility of survival of trade relationships between final products and parts and components in intra-East Asian machinery trade. First and foremost, compared to final products, machinery parts and components are traded through more stable and longer-lived relationships among East Asian countries. Second, trade relationships of parts and components have been maintained between countries even at a long distance, regardless of the exchange-rate fluctuations. Trade relationships of final products, on the other hand, are more likely to be sensitive to the level of trading cost as well as the exchange-rate fluctuations. Furthermore, empirical results provide intriguing clues to facilitate the development of more stable trade relationships all over the region.

This paper offers a new insight to accumulated studies on intra-regional trade and production networks in East Asia. It also contributes to a pioneering work on duration of trade by Besedeš and Prusa (2006a; 2006b). Despite an emerging body of literature on trade at the country-product level, the duration of trade has not received much attention until very recently. Besedeš and Prusa (2006a), who first investigated the duration of the US imports, find the country-product-level trade to be surprisingly volatile with the median duration of four year. As their companion paper, Besedeš and Prusa (2006b) highlight that differentiated products have a longer median duration and a higher possibility of survival than homogeneous products, based on a search cost model of international trade. Besedeš (2008) provides additional facts on the survival of the US imports from a search cost perspective. The prevalence of short-lived trade relationships has been also found in just a few studies including Nitch (2007) for German imports and Blyde (2008) for the exports from Latin American countries.

The rest of this paper proceeds as follows: the next section outlines the duration and volatility of trade relationships in intra-East Asian machinery trade. Focusing on the difference between final products and parts and components, the survival analysis is performed in two steps. As a first step, Section 3 examines the possibility of survival of trade relationships, employing the Kaplan-Meier method. As a second step, Section 4 examines the interplay of factors that may affect the duration of trade, employing the Cox proportional hazard model. Section 5 discusses the interpretation of the empirical results and its policy implication. And the last section concludes.

2. The Duration and Volatility of Trade Relationships in Intra-East Asian Machinery Trade

This section starts by describing the trade data used throughout this paper. Section 2.2 provides underlying evidence for the difference in the duration and volatility of trade relationships between final products and parts and components in intra-East Asian machinery trade.

2.1. Data Description

To examine trade relationships in intra-East Asian machinery trade, this paper uses bilateral trade data at the six-digit level of Harmonized System (HS) 1992 from 1993 to 2006 obtained from the United Nations Commodity Trade Statistics Database (UN Comtrade).[2] The HS six-digit level is the most detailed disaggregated level of trade data that is internationally comparable and publically available. There exist 1,124 product lines at the six-digit level of HS 1992 just for machinery industry and 5,040 product lines for all industries.

This paper focuses on bilateral trade relationships among nine East Asian countries, namely China, Hong Kong, Indonesia, Japan, Malaysia, the Philippines, Rep. of Korea,

[2] See Appendix A for the details of trade data used throughout this paper.

Singapore, and Thailand. The machinery industry of interest includes general machinery (HS84), electric machinery (HS85), transport equipment (HS86-89), and precision machinery (HS90-92). The HS classification codes are grouped into final products and parts and components, following Ando and Kimura (2005). 1,124 product lines of machinery industry consist of 688 final products and 436 parts and components.

Before examining the duration and volatility of trade relationships, Table 1 compares the yearly variation of trade volume between final products and parts and components for intra-East Asian machinery trade.[3] To outline the different intra-regional trade patterns, the coefficients of variance for trade value at constant prices during 1993-2006 are calculated by exporter-importer-product pair, the mean of which is reported by exporter. Bilateral trade volumes of final products fluctuate from year to year more than those of parts and components, irrespective of exporter country. As for all the exporter-importer-product pairs, the mean of coefficients of variance for final products is 1.41, which is higher than that for parts and components, 1.27.

== Table 1 ==

Although Table 1 offers insight into the difference in the volatility of trade relationships between machinery final products and parts and components, the calculation of coefficient of variance for trade volume ignores the aspect of how often and how long a trade relationship is active during the period of interest. In other words, the existence of zero trade flows at the product-line level is overlooked. The next subsection looks into the duration as well as volatility of trade relationships by focusing on whether or not a product is traded between an exporter-importer pair in a given year, irrespective of its volume.

[3] After the cutoff value of $500 is applied, all trade data are deflated by the wholesale price index in the U.S. to obtain a constant dollar series.

2.2. The Duration and Volatility of Trade Relationships

For each exporter-importer-product pair, we can identify whether a trade relationship is active in a given year and how long a trade relationship is continued without interruption. Table 2 reports the basic statistics for the number of years in which a trade relationship is active during 1993-2006 for intra-East Asian machinery trade. The maximal possible number of years active is 14 years. The figures are compared between final products and parts and components.

== Table 2 ==

The upper part of the table reports the basic statistics for all the potential exporter-importer-product pairs: mean, median, cumulative percentages by the number of years active, and the size of observations. The size of observations for all the machinery products is 79,804, which equals 1,124 product lines multiplied by 71 pairs. Note that data for Singapore's imports from Indonesia, which only have been officially reported since 2003, are not included in the sample used in this and the following sections. The lower part of the table excludes exporter-importer-product pairs inactive throughout 1993-2006.

The trade relationships of parts and components are more active than those of final products during the period, even when exporter-importer-product pairs inactive throughout the period are excluded. For all the potential exporter-importer-product pairs (without those inactive throughout the period), the mean number of years active is 6.7 (8.3) for final products and 9.2 (10.3) for parts and components. This result can be interpreted as a reflection of the difference in the duration and volatility of trade relationships between final products and parts and components. Our interest is then turned towards the length of time a particular product is continuously traded between an exporter-importer pair. For instance, if country *i* started to export product *h* to country *j* in 1994 and ceased to export the product in 1998, the trade relationship is regarded as having a spell length of four. As some of trade relationships were broken off and restored after a certain period, which is referred to as multiple spells, the number of spells by exporter-importer-product pair as well as their lengths should be examined.

Tables 3 and 4 report the basic statistics for the number and length of spells, focusing on exporter-importer-product pairs active at least one year during 1993-2006. Note that, as multiple spells are treated as independent, the size of observations in Table 4 is different from that in Table 3. Since we cannot identify which particular firms of exporter country *i* and importer country *j* are involved in a trade relationship of a product *h* with the aggregated data at the country level used in this paper, it would be better to treat multiple spells accompanied by a certain period of interruption as independent. Separated spells of an exporter-importer-product pair would involve different firms of exporter and importer countries. The minimal possible number of spells is one when a trade relationship is active without any break followed by resumption, and the maximal possible number is seven in an extreme case. The minimal possible length of spells is one year, and the maximal possible length is 14 years when a trade relationship is persistent throughout the period.

== Tables 3 and 4 ==

The mean number of spells is 1.9 for machinery final products and 1.7 for parts and components. For final products, 53% of exporter-importer-product pairs experience multiple spells, about a half of which, 27% experience more than two spells. For parts and components, the median number of spells is one, meaning a single spell, but still 41% of exporter-importer-product pairs experience multiple spells. Even with aggregated trade data at the country level rather than data on the firm-level export activities, the break and restoration of trade relationships occur at significant frequency particularly for final products.

The mean length of spells is 4.3 years for final products and 6.1 years for parts and components. The median length of spells is remarkably short: two years for final products and three years for parts and components. For final products, 57% of trade relationships last at most two years, three third of which, 43% are observed only for a single year. For parts and components, 44% of trade relationships are continued for four years or more, yet the other 44% last at most two years. Short-lived trade relationships are more prevalent than expected particularly for final products.

The descriptive analyses in this section suggest that, compared to final products, machinery parts and components are likely to be traded through more stable relationships without interruption for a longer period of time. Stimulated by these facts, the next two sections explore the difference in the possibility of survival of trade relationships between final products and parts and components by estimating the survival and hazard functions.

3. The Survival of Trade Relationships

This and the next sections perform the survival analysis in two steps, highlighting the difference in the possibility of survival of trade relationships between final products and parts and components in intra-East Asian machinery trade. As a first step, this section examines the possibility of survival of trade relationships, employing the Kaplan-Meier method. As a second step, the next section examines the interplay of country-specific and pair-specific characteristics that may affect the duration of trade, employing the Cox proportional hazard model.

3.1. Nonparametric Kaplan-Meier Estimation

Let T be a non-negative random variable denoting the time to a failure event. As our interest is in the length of time (years) until country i discontinues to export product h to country j, an event which is referred to as a “failure,” we assume T is a discrete variable. The survival function of T is given by

$$S(t) = \Pr(T > t),$$

which means the probability of surviving beyond time t. Note that $S(t)$ equals to one at $t = 0$ and decreases towards zero as t increases. The hazard function is given by

$$h(t) = \Pr(T = t \mid T \geq t),$$

which is also known as instantaneous failure rate. The survival and hazard functions are just alternative ways to express the same underlying failure process.

In practice, to estimate the survival and hazard functions, we assume that we have K independent observations denoted (t_k, c_k), $k = 1, 2, \ldots, K$, where t_k is the survival time, or the length of spell, and c_k is the censoring indicator variable, which takes a value of one when failure occurred, and zero otherwise. The nonparametric Kaplan-Meier product limit estimator of the survival function is then

$$\hat{S}(t) = \prod_{k|t_k \leq t} \left(\frac{n_k - d_k}{n_k} \right),$$

where n_k is the number of subjects at risk of failure at time t_k and d_k is the number of observed failures at time t_k.[4] Note that Kaplan-Meier estimator uses information of both right-censored and non-right-censored observations, the latter of which is observed failures.[5]

3.2. Kaplan-Meier Estimates

Estimated Kaplan-Meier survival rates are reported in Table 5 and the corresponding survival curves are graphed in Figure 1. Estimates are compared between machinery final products and parts and components. The benchmark result for all the observed spells during 1993-2006 is reported in the first two rows in the table and shown in the top panel of the figure.

== Table 5 and Figure 1 ==

[4] The corresponding hazard function is estimated by taking the ratio of subjects that fail to the number of subjects at risk of failing in a given period t.

[5] As for the left-censoring issue, robustness exercise is to be performed using the modified sample.

The shape of estimated survival curves for machinery final products and parts and components look similar. Both survival curves are downward sloping with a decreasing slope, indicating that the hazard rate decreases as the survival time becomes longer. In other words, the conditional probability of failure is quite high in the early years, but then sharply decreases once a trade relationship lasts for a certain period of time: a kind of threshold effect is observed. A substantial portion of trade relationships fail within the first four years, especially in the first year when the hazard rates are 38% and 28% for final products and parts and components, respectively. For the later years, on the other hand, survival rates slowly decline by only 5-7% between the fourth and seventh years, and remain nearly constant afterwards. There is little additional possibility of failure beyond the seventh year, because most of the long-lasting spells ended in 2006, the end year of the sample, and are classified as censored rather than failures.

Although the survival curves are similar in shapes, survival rates are higher for parts and components than final products at any point of time, as is clear from the figure. The difference of survival function between final products and parts and components is statistically significant using the log-rank test. One half of trade relationships of final products fail during the first two years, whereas, for parts and components, 40% fail during the first two years and the median survival time is five years. As a related finding, the survival curve becomes nearly flat at the earlier point of time for parts and components. The threshold duration for a longer survival appears to be shorter for parts and components than final products.

3.3. Robustness Check

Two kinds of exercises are performed. First, to address the left-censoring issue, survival functions are re-estimated for the sample without spells which begun in 1993. As the beginning year of the data used in this paper is 1993, there is no information on whether trade relationships begun exactly in 1993 or in some prior year. For the end year of data, on the other hand, trade relationships may have failed exactly in 2006 or may be persistent afterwards. Since Kaplan-Meier survival rates are estimated using information of not only observed failures but also right-censored observations, as mentioned above, it must be appropriate to interpret the length of right-censored spells as a minimum.[6]

Second, regarding possibly incorrectly recorded multiple spells due to measurement error, survival functions are estimated using the modified sample. As pointed out by Besedeš and Prusa (2006a; 2006b), if the interruption time between spells is quite short, the gap is suspected to be incorrectly recorded and it may be more appropriate to regard the two spells before and after the gap as a single longer spell. A one-year gap may be partly due to a discrete nature of trade data which is compiled on an annual basis. The length and number of spells are adjusted by assuming that a one-year gap between spells which last at least two years is a result of a recording error.[7]

While estimated survival rates for the sample without 1993-origin spells decrease, those for the modified sample with the one-year-gap adjustment increase slightly at each point of time. Yet, the aforementioned two features of survival functions are robust for different samples. The decreasing slopes of survival curves suggest the threshold effect for a longer survival; that is, once a trade relationship is established and has lasted for the first few years, it is likely to be persistent afterwards. As for the other feature, the difference of survival function between final products and parts and components remains statistically significant.

For further reference, survival functions are estimated only for the first spells of respective exporter-importer-product pairs and for single spells. That is, subsequent spells after

[6] Similarly, the length of left-censored, 1993-origin spells can be interpreted as a minimum in the benchmark sample.

[7] Besedeš and Prusa adjust the length of spells by assuming any one-year gap is an error. For the sample used in this paper, however, about one fourth of the observed spells, are subject to be merged accordingly. As this paper basically uses import data, it isn't very likely that all those spells are incorrectly reported even though custom authorities must carefully inspect inbound cargoes to collect import duties. Although I considered alternative criteria to adjust possibly incorrectly recorded one-year gaps, results did not change qualitatively.

a certain period of interruption and all the exporter-importer-product pairs with multiple spells are excluded, respectively. Looking at estimates for the first spells, survival rates are slightly higher at each point of time, but not much different than the benchmark result. For single spells, on the other hand, survival rates remain nearly at a constant beyond the first year for both machinery final products and parts and components. Although estimated survival rates vary among different samples, it is striking that the two features of the survival functions still hold.

4. The Factors behind the Survival of Trade Relationships

In order to control for country-specific and pair-specific characteristics that may influence the duration of trade, the Cox proportional hazards model is estimated. As well as confirming the difference in the possibility of survival of trade relationships between machinery final products and parts and components, this section examines how covariates affect the hazard rate.

4.1. Semi-parametric Cox Proportional Hazards Model

The semi-parametric Cox proportional hazards model asserts that the hazard rate for the m-th subject in the sample is

$$h(t \mid \boldsymbol{x_m}) = h_0(t)\exp(\boldsymbol{x_m}\beta),$$

where $\boldsymbol{x_m}$ denotes a vector of m-th subject's covariates and coefficients β are to be estimated.[8] The Cox model is by far the most popular of choices in the analysis of survival data. A particular advantage of the model is that the baseline hazard function, $h_0(t)$, is left unspecified and not estimated. What is assumed is that the covariates multiplicatively shift the baseline hazard which is common to all the subjects. In this regard, however, estimation is to be stratified by machinery subsector, namely general machinery, electric machinery, transport equipment, and precision machinery, allowing the baseline hazard to vary among strata. In addition, the Cox

[8] As the Cox model is a continuous model while the survival data used in this paper is on an annual basis, in which some failures occur at the same survival time (year), the Breslow (1974)'s approximation is assumed so as to treat tied failures.

model has no intercept because the intercept is subsumed into the baseline hazard.

The hazard rate for individual subject equals to the baseline hazard when the value of all covariates is set to zero. Exponentiated respective coefficients are then interpreted as the ratio of the hazard rates, which is referred to as hazard ratio, for a one-unit change in the corresponding covariate. Hazard ratio is greater than one if the corresponding covariate negatively affects the duration of trade relationships, and vice versa. A ratio equal to one implies no impact on the duration of trade relationships.

Firstly, to confirm the different possibilities of survival of trade relationships between machinery final products and parts and components, the Cox model is estimated simply using time-invariant covariates as well as control variables. Distance and dummy variables for common official language and contiguity are included, since, in the gravity literature, it is well known that countries at smaller distance and sharing a common language and a common border tend to trade more with each other.[9] Those variables might also affect the duration of trade relationships through pushing up or lowering the cost of trading.

To control for the initial size of transaction, the logarithm of trade value in the first year is included.[10] A trade relationship started with a smaller trade value at the country level, which is probably economically less important for either or both of exporter and importer countries in the beginning, may face a greater risk of failing. Instead of applying the cutoff value to trade data, the initial trade value is taken into consideration.

Regarding the prevalence of multiple spells, two control variables are included. One is a dummy variable for subsequent spells, following Besedeš and Prusa (2006b). The experience of failure of trade relationships may lead another failure; on the other hand, a trade relationship restarted after a certain period of no trade may not fail again, owing to accumulated information about the trade counterpart at the country level. In either case, the possibility of survival will

9 See Appendix B for the data sources of covariates.
10 Trade data are deflated by the wholesale price index (WPI) in the U.S. to obtain a constant dollar series.

depend on the experience of failure. Although multiple spells are treated as independent because separated spells would involve different firms of exporter and importer countries, the subsequent spells would be related to the prior spells at the country level.

The other is a dummy variable for exporter-importer-product pairs for which breaks and restoration of trade relationships are observed very frequently. As is clear from Table 3, about 8%, a non-negligible portion of exporter-importer-product pairs have four or more spells, meaning that they experienced breaks accompanied by restoration three times or more in just 14 years. Looking into HS six-digit codes of those exporter-importer-product pairs, there seems to be product-specific factor behind the extraordinary experiences, as well as country-specific and pair-specific factors. Some product lines such as equipment and facilities might not necessarily be traded bilaterally every year even at the country level.[11] Or, some product lines might be more likely to be unintentionally misclassified as a different product-line due to unfamiliarity with the product or as a different country of origin due to entrepôt trade (See Yeats, 1995). A dummy variable which takes a value of one if an exporter-importer-product pair in question have four or more spells during the period and zero otherwise is then included.

Next, the survival data are split at every observed failure time, i.e., at every year, for respective spells, which enables us to estimate the Cox model using time-dependent covariates as well as time-invariant variables. As for country-year-specific characteristics, exporter country's GDP and importer country's GDP are included, since, in the gravity literature, it is well known that larger countries tend to trade more with each other, which might affect the duration of trade relationships as well.[12] Supplier firms located in larger economies might be

[11] For instance, in the multiple spells sample, machines for extruding, drawing, texturing or cutting man-made textile materials (HS844400) and machinery for the extraction or preparation of animal or fixed vegetable fats or oils (HS847920) are observed at most significant frequency. For those products, about one fourth of exporter-importer pairs have experienced stops and restarts of trade three times or more in just 14 years.

[12] As this paper focuses on machinery trade, we would prefer value added of machinery industry of its own (ideally, disaggregated by product type) to GDP as a variable indicating the size of economic activities of machinery industry. Due to lack of data publicly available, we

able to maintain a longer trade relationship due to larger production capacities. Meanwhile, a larger pool of potential buyers might ease accommodating demand fluctuation through switching buyers within a country, leading to a longer trade relationship at the country level.

The firm's ability to maintain trade relationships might also be affected by the competitiveness environment in an exporter country, which is assumed to be related to the institutional framework, as well as institutional stability in an importer country. To capture institutional quality for both exporter and importer countries, country credit rating indicators compiled by *Institutional Investor* are included. The credit ratings are based on evaluations of the country's creditworthiness, provided by economists and international banks. The numerical ratings range from 0 to 100, with 100 corresponding to the lowest chance of sovereign default on the country's foreign currency debts.

The possibility of survival of trade relationships will depend not only on exporter-importer-product-pair-specific experience, which is captured by the subsequent spells dummy, but also on importer country's experience of purchasing a particular product from abroad. The cumulative number of supplier countries, which is counted for respective importer-product pairs excluding an exporter country in question itself, is then included. A trade relationship which is commenced under a competitive market environment with a large number of potential suppliers for a particular product might be more likely to be lasting.

As for pair-year-specific characteristics, the absolute value of the difference in per capita GDP between exporter and importer countries is included as a proxy for wage differential, which may reflect different factor intensity, or production technology, and factor endowment. These differences in production conditions are presumed to encourage cross-border production sharing, leading to a longer-lasting trade relationship.

To capture supplier firm's competitiveness in terms of relative trading cost, the year-on-year percentage change in real exchange rate (RER) for exporter country's currency to

have no alternative but to employ GDP as a proxy for economic size of machinery industry.

importer country's currency is included.[13] An increase in RER reflects that an exporter country's currency has weakened relative to importer country's currency with consideration to inflation in respective economies. If an exporter country's currency depreciates, since its supplier firms will become more competitive relative to those located in the export counterpart, the suppliers might be less likely to exit from the market.

4.2. Cox Hazards Estimates

Table 6 provides the Cox proportional hazards estimates for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006, using time-invariant covariates. Besides the aforementioned control variables, exporter and importer country fixed effects are included to control for unobserved country-specific characteristics. The sample and the trade relationships of interest are listed at the top of each column, and the covariates and control variables are in the first left column of the table. Units in which respective variables are measured are in parentheses.[14] Estimated coefficients are expressed in terms of hazard ratios.

== Table 6 ==

The benchmark result for all the observed spells during 1993-2006 are reported in the left part of the table. The estimation for the sample including all machinery products contains a dummy variable which takes a value of one if a trade relationship is of parts and components. Note that, in this specification, the hazard function of final products is assumed to be proportional to that of parts and components, sharing the same baseline hazard. The estimates for all the machinery products confirm the difference in the possibility of survival of trade

[13] The annual average of nominal exchange rate is deflated by WPI for each country. As for China and the Philippines, which have not reported WPI during the period, the consumer price index is used instead of WPI as a deflator.

[14] Note that the unit in which a variable is measured makes no substantive difference..

relationships between final products and parts and components. Letting trade relationships of final products be the benchmark, those of parts and components have a 32% lower hazard rate. In other words, for parts and components, once a trade relationship is developed, it is 32% less likely to be broken off.

As for the effects of covariates, a larger distance between exporter and importer countries shifts up the hazard rate by 5.4% per one thousand kilometers. Although a common border does not have a statistically significant effect on the possibility of survival of trade relationships, a country sharing a common official language with the trade counterpart has a 10% lower the hazard rate than otherwise. In addition, the duration of trade relationships is positively associated with the initial size as well as the prior experience of failure.

One concern is that the baseline hazards might be shaped differently by product type. In the next two columns of the table, the estimation is conducted separately for final products and parts and components, using the same covariates. In this specification, the effects of covariates of interest are assumed to be different between final products and parts and components, as well as allowing the baseline hazards to differ by product type. By employing this approach, while we do not care how the product type proportionally shifts a common baseline hazard, we can measure the effects of covariates correctly for each product type.

The effects of covariates are similar in direction but different in magnitude between final products and parts and components. Looking at the estimated coefficients for distance, the hazard rate of final products increases by 5.9% due to a larger distance per one thousand kilometers, but for parts and components, the increase is smaller, at 4.7%. Similarly, the decrease in the hazard rate due to a common language is larger for final products than parts and components. Since those variables will push up or lower the cost of trading, trade relationships of parts and components appear to be less sensitive to the level of trading cost.

Next, Table 7 provides the Cox hazards estimates for intra-East Asian machinery trade relationships during 1993-2006, using time-dependent covariates as well as time-invariant variables. In addition, exporter, importer, year fixed effects are included to control for unobserved country-specific and year-specific characteristics.[15] Note that the number of spells equals to the corresponding figure in Table 6, but the size of observations does not. There are much more observations as the observed spells are split at every year to be linked to time-dependent characteristics.

== Table 7 ==

The benchmark result for all the observed spells are reported in the left part of the table again. Even after considering time-dependent aspects, the estimates confirm the difference in the possibility of survival of trade relationships by product type. If we assume that all the machinery products share the same baseline hazard, trade relationships of parts and components have a 20% lower hazard rate, compared to those of final products. Trade relationships of parts and components still face relatively a smaller risk of failing.

As for the effects of covariates on the hazard rate for all the machinery products, a larger distance shifts up the hazard, while a common border as well as official language lowers the hazard. Coefficients for time-dependent covariates are also estimated as expected: larger countries as measured by GDP face a lower hazard rate, either in terms of differences across time or countries. Exporter country with a higher institutional quality as measured by country's credit rating faces a lower hazard. Importer country with a more competitive market environment as measured by the cumulative number of supplier countries faces a lower hazard. A larger wage differential between exporter and importer countries, which is replaced by the absolute value of the difference in per capita GDP between the countries as a proxy, lowers the hazard. A depreciation of exporter country's currency as measured by the year-on-year

[15] The failure's share of the observed trade relationships has hovered around 12% level; however, the share in 1998 is remarkably high, at 17%, due mostly to the Asian crisis, which suggest the need for controlling year-specific effect.

percentage change in RER lowers the hazard.

Contrary to normal expectation, however, the coefficient for importer country's credit rating is estimated to shift up the hazard rate. Given the development of production networks within the East Asian region, one way to interpret this result is that production shifts, i.e., shifts from exporting to producing a product in a host country, possibly lead to the stop of exports of the product from the home country, as a country with a higher institutional quality would be an attractive investment destination to which foreign corporations relocate production facilities.[16]

Once the model is estimated separately for final products and parts and components, it is clear that the effects of covariates are similar in direction but different in magnitude and significance. First and foremost, the estimated coefficients for variables which will push up or lower the trading cost including distance, a common language, and contiguity, are larger in magnitude for the baseline hazard of final products than that of parts and components. Even after incorporating time-dependent covariates, trade relationships of parts and components are less likely to be sensitive to the level of trading cost. Furthermore, the coefficient for the year-on-year percentage changes in RER is less than one and significant in the final products equation, but statistically insignificant in the parts equation. Although an appreciation of exporter country's currency increases the hazard rate for final products, the survival of trade relationships of parts and components does not affected by the fluctuations in RER.

4.3. The Impact of the AFTA

To examine whether free trade agreements (FTAs) facilitate more stable and long-lasting trade relationships, a dummy variable which is given unity if both exporter and importer countries belong to an ASEAN Free Trade Area (AFTA) is included. During the period of interest, ASEAN countries have made significant progress in lowering intra-regional tariffs through the

[16] Further investigation into the effect of production shift on the duration of trade relationships is beyond the scope of this paper.

Common Effective Preferential Tariff (CEPT) scheme for the AFTA.[17] As for the six original ASEAN signatories, intra-regional tariffs have been gradually reduced since 1993. Signing a FTA will reduce the costs of servicing the market of the export counterpart. FTAs may also facilitate long-lived trade relationships among member countries by restricting competition from non-members. A dummy variable for the membership in the AFTA is expected to lower the hazard rate.

The estimates reported in the right part of Table 7, however, indicate an insignificant impact of the AFTA on the duration of trade relationships among member countries. The result seems to suggest that the progress of intra-regional tariff reductions should be taken into account. The accelerated AFTA targets were fully realized with some flexibility in 2002, before the original target date. As of January 2002, intra-regional tariffs on 96% of the CEPT Inclusion Lists (IL) which make up 98% of all the tariff-lines of the original signatories had been reduced within the range of 0-5%. In addition, Malaysia and Singapore had already achieved the target of fully eliminating import duties on 60% of their products in the CEPT IL. With the year 2002 as a turning point for the progress of trade liberalization within the region, the AFTA dummy variable is therefore divided into two according to the year of transaction.

In case that the extent to which intra-regional tariffs have been reduced is taken into consideration, the coefficients are found to be significant: the membership in the AFTA lowers the hazard rate by 14% in and after the year 2002, although it shifts up the hazard before then. The positive effect of the CEPT scheme for the AFTA on the duration of trade relationships in the latter period is also found separately for final products and parts and components. Meanwhile, even after considering the impact of the AFTA, the findings in the benchmark results still hold.

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[17] As for the AFTA and the CEPT scheme, see the web page of the ASEAN Secretariat (http://www.aseansec.org/).

4.4. Robustness Check

The same Cox model is re-estimated using two different samples so as to examine whether the differences between machinery final products and parts and components are robust. As with Section 3.3, one is the sample without 1993-origin spells and the other is the modified sample with the one-year-gap adjustment. As for the specification using only time-invariant variables, the estimates for the two different samples are reported in the middle and right part of Table 6. The patterns of estimated coefficients are similar to the benchmark result, except that the coefficient for language dummy is statistically insignificant in the parts equation estimated using the sample without 1993-origin spells.

As for the specification using time-dependent variables as well as time-invariant variables, the estimates for the two different samples are reported in the left part of Table 8. Although the magnitude of the effect of respective covariates on the hazard rate varies among different samples, the following features remain statistically significant even after considering time-dependent aspects. One feature is that trade relationships of parts and components face relatively a smaller risk of failing. The other is that trade relationships of parts and components are less likely to be sensitive to the level of trading cost. Moreover, the survival of trade relationships of parts and components still does not depend on the fluctuations in RER, unlike that of final products, although the coefficient for RER loses significance at the 5% level in the final products equation estimated using the one-year-gap-adjusted sample.

== Table 8 ==

For further reference, the specification incorporating time-dependent variables is estimated for the first spells and for single spells. The result for the first spells sample reported in the second right part of Table 8 shows a similar pattern of estimated coefficients to the benchmark result except the contiguity dummy variable in the final products equation. The estimates for the single spells sample, on the other hand, differ in some respects from the benchmark result. With regard to the common features for different samples, although the coefficient for distance is larger in magnitude in the final products equation as expected, the coefficient for the contiguity dummy becomes more than one in both the final products and parts equations, and the magnitude of coefficient for the language dummy is reversed between the equations. These results seem to be due partly to multicolinearity issue.[18]

5. Interpretation and Policy Implication

The survival analyses in the last two sections confirm the difference in the possibility of survival of trade relationships between final products and parts and components in intra-East Asian machinery trade. After considering the interplay of factors that may affect the duration, trade relationships of parts and components face a 20-32% smaller risk of failing with respect to those of final products. Parts and components are more likely to be traded through long-lived relationships than final products.

The comparison of the pattern of estimated coefficients between machinery final products and parts and components provides intriguing results to understand the difference in the factors behind the survival of trade relationships by product type. First, compared to final products, trade relationships of parts and components are less likely to be sensitive to distance and whether exporter and importer countries share an official language and border. As the trading cost is mounting in response to distance and might be reduced due to a common language and border, the survival of trade relationships of parts and components seems to be less affected by the level of trading cost. Second, the survival of trade relationships of parts and components is unaffected by the fluctuations in RER, unlike that of final products.

These findings indicate that longer-lived trade relationships of machinery parts and

[18] By focusing on single spells, the correlation between the contiguity and the language dummies becomes higher. The correlation between exporter country’s GDP and its credit rating also becomes higher for the single spells sample.

components have been developed between East Asian countries even at a long distance, regardless of the fluctuations in RER. A higher possibility of survival of trade relationships of parts and components is thought to be due to the relation-specific nature of the transaction of parts and components. Since the manufacturing of parts and components requires coordination between production processes, unlike final products, once a transaction is started, it might be more likely to be a stable relationship.

As for the insensitivity of trade relationships of parts and components to the RER fluctuations, the effect of country's currency appreciation/depreciation on the trade balance appears to be different between trade involving goods of joint production across borders and traditional trade in products made entirely in one country (See Arndt, 2004). If country's imported parts or components become part of its exports and its exports enter into its imports, the exchange-rate effect on the price of exports dominated in one currency might be offset by the exchange-rate effect on the price of imports expressed in the other currency. Cross-border production sharing changes the pass-through of country's currency appreciation/depreciation to its export/import price. The insensitivity of trade relationships of parts and components to the RER fluctuations can be interpreted as a reflection of active back and forth transactions across the region as well as indicating their intrinsic stability.

Furthermore, the conclusion of this paper can be interpreted as a variant of the findings of a series of studies by Besedeš and Prusa (2006b) and Besedeš (2008). They investigate the duration of the US imports and find that differentiated products have a longer duration than homogeneous products. As pointed out by Besedeš and Prusa (2006b), a longer duration of trade relationships of differentiated products can be explained by relation-specific factors which are intuitively plausible and consistent with many theoretical models.[19] Given the aforementioned relation-specific nature of the transaction of parts and components, although

[19] As for the observed short-lived trade relationships, Besedeš and Prusa (2006a) discuss potential explanations including the Ricardian comparative advantage model, the product cycle model as well as the model of trade and search costs.

Besedeš (2008) himself finds that intermediate goods face a higher risk of failure than final products, a longer duration of trade relationships of parts and components should be explained by the same token.

The possibility of survival of trade relationships is inseparably related to country's trade growth. In terms of export growth, as well as discovering a new export partner, the firm's ability to maintain the existing trade relationships would be crucial. Indeed, the deepening of long-lasting trade relationships is an important driving force behind a striking growth of intra-East Asian machinery parts and components trade. For every East Asian country, a rapid growth of intra-regional exports of machinery parts and components is mostly attributed to larger quantities of each products (i.e., the intensive margin), rather than a wider set of products (i.e., the extensive margin). The export growth contribution of products exported throughout 1993-2005 without interruption is more than 91% (except Indonesia, more than 98%).[20]

In contrast, for machinery final products, the export growth contribution of products exported throughout the period varies among countries, ranging from -13% for Singapore to 78% for Rep. of Korea.[21] More interestingly, however, the export growth contribution of products exported both in the beginning and end of the period is more than 91% for every country. These two facts mean that non-negligible trade relationships, which are economically important at least at the country level, have experienced breaks and restorations at least once during the period. A lower possibility of survival of trade relationships of final products is unambiguously related to a limited contribution of long-lived products to the intra-regional export growth, compared to parts and components.

If the possibility of survival of trade relationships can be improved in some way, there appears to be still a considerable room for growth of intra-East Asian machinery exports,

[20] Author's calculation based on the data obtained from UN Comtrade (HS 1992, six-digit).

[21] For simplicity, the pattern of the export growth contribution is illustrated by excluding Hong Kong (-193%) and Japan (-119%) which experienced a negative growth of intra-East Asian machinery final products exports during the period.

particularly for final products. In this context, policy makers would be interested in how to support and facilitate firms to maintain ongoing trade relationships. As is clear from the Kaplan-Meier estimates, we can observe a kind of threshold effect for a longer survival of trade relationships. Specifically, once a trade relationship is developed and has survived for the first few years, it is likely to be persistent afterwards. Given this result, any policy aimed at supporting and facilitating firm's export activities would be particularly important during the early stage of trade relationship when the risk of failure is still high.

Moreover, a significant positive impact of the CEPT scheme for the AFTA on the duration of trade relationships suggests that the following FTAs concluded or currently negotiated in the East Asian region might further contribute to the development of long-lasting trade relationships.[22] In particular, FTAs between Japan/Korea/China and ASEAN appear to have potential for a region-wide development of more stable trade relationships, by facilitating network-forming multinationals to spread fragmented production processes more efficiently across the region. In addition, prior to the utilization of FTAs, ASEAN and China have provided a wide range of tariff reduction and exemption schemes, such as tariff reductions of IT products under the scheme of the Information Technology Agreement (ITA), export processing zones as well as arrangements to grant enterprises bonded status, so as to attract foreign direct investments. Building long-lasting trade relationships across the region through more advanced utilization of FTAs as well as trade liberalization and facilitation policies might enhance the great potential for sustainable co-development of East Asian countries.

6. Conclusion

The aim of this paper was to find the difference in stability between the transactions of intermediate goods in international production networks and other transactions. From the

[22] JETRO White Paper 2007 (JETRO 2007: pp. 135-47) presents the present status of utilization of the CEPT scheme as well as other FTAs in the region (http://www.jetro.go.jp/en/stats/white_paper/).

perspective of the duration and survival of bilateral trade relationships at the product-line level, the novel empirical approach sheds light on the stability of international production networks in East Asia. Compared to final products, machinery parts and components are traded through more stable and longer-lived relationships among East Asian countries. Trade relationships of machinery parts and components have been developed and maintained between countries even at a long distance, regardless of the RER fluctuations. Trade relationships of machinery final products, on the other hand, are more likely to be sensitive to the level of trading cost as well as the RER fluctuations. Although the term “fragmentation” evokes the image of foot-loose investments, once the production networks are created, trade relationships are rather stable due to the relation-specific nature of transactions.

The deepening of long-lasting trade relationships appears to be crucial to consolidate stable, sustainable export growth. During the early stage of trade relationship when the risk of failure is still high, there is room to hope for the creation and the implementation of mechanisms to support and facilitate firm’s export activities. In terms of the East Asian regional economy as a whole, more advanced utilization of FTAs as well as trade liberalization and facilitation policies might accelerate the building and networking of long-lasting trade relationships across the region. In addition to maintaining ongoing trade relationships, how to recover a new trading partner and join in the production networks appears to be another crucial issue faced by relatively less developed countries in the region, and it is ripe for future research.

Appendix A. Trade Data

This paper basically uses bilateral import data from the standpoint of reliability, because country of origin is more closely verified due to tariff regulations although final destination may not be known at time of export. An advantage of consistently employing HS 1992 classification codes for trade data from 1993 to 2006 is that we do not need to concern about the complicated mergers and branching of codes due to the update of classification.

I modified data as follows: First, data for the Philippines' imports, which only have been reported according to the HS classification since 1996, are replaced by data for exports to the Philippines. The export data are adjusted by the c.i.f. / f.o.b. ratio specific to the machinery industry sub-sector and exporter-importer pair, which is calculated using the corresponding data reported according to the Standard International Trade Classification (SITC) Rev.3. Second, since the annual data at the HS six-digit level below $500 (current US$) are not reported before 2000, trade flows below $500 are treated as if there was no trade at all for all the years in the sample.

Appendix B. Data Sources for Other Variables

Variable	Source
Distance Contiguity dummy Language dummy	The CEPII's distance measure database
GDP (constant 2000 US$) Per capita GDP (constant 2000 US$)	The World Bank's World Development Indicators (WDI) Online
Country credit rating	Institutional Investor
Nominal exchange rate Wholesale price index (2000=100) Consumer price index (2000=100)	The IMF's International Financial Statistics (IFS)

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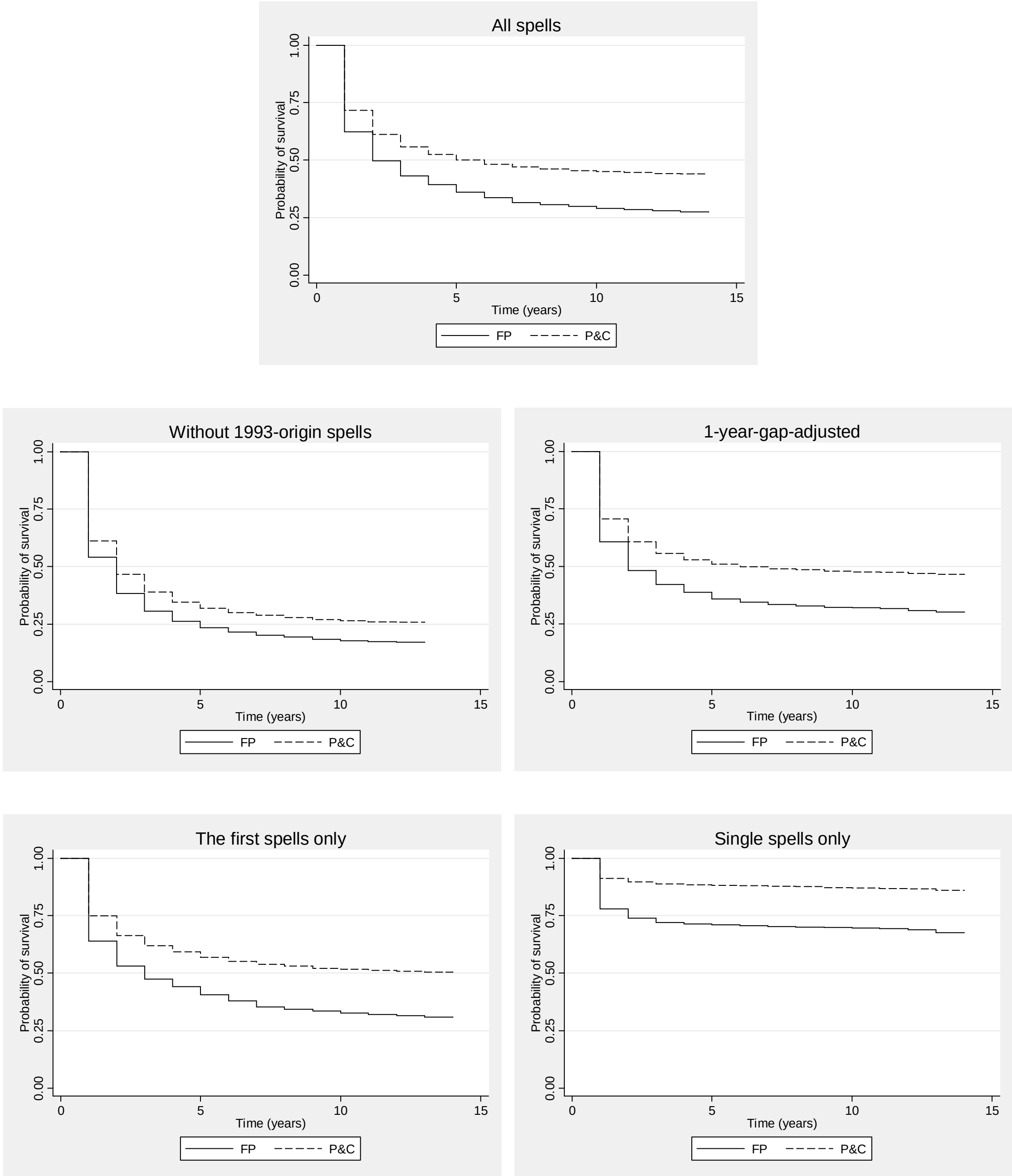
Figure 1: ***Kaplan-Meier estimates of survival curves for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006: by product type***



Notes: The difference of survival function between final products and parts and components for each sample is significant at the 1% level using the log-rank test.
Source: Author’s calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 1: ***Average of coefficient of variance for bilateral trade volume at the product-line level in intra-East Asian machinery trade during 1993-2006: by exporter***

Exporter	FP	P&C
China	1.33	1.22
Hong Kong	1.46	1.30
Indonesia	1.47	1.33
Japan	1.16	0.95
Malaysia	1.48	1.36
Philippines	1.58	1.48
Rep. of Korea	1.45	1.26
Singapore	1.43	1.23
Thailand	1.53	1.41
All bilateral trade relationships	1.41	1.27

Notes: All values are calculated at constant prices.
Source: Author's calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 2: ***Number of years active during 1993-2006 for exporter-importer-product pairs in intra-East Asian machinery trade***

	Mean	Median	Cumulative percentages (%)				Obs.
			0	1	7	13	
All potential trade relationships							
FP	6.7	6	20.2	29.5	55.7	78.8	48,848
P&C	9.2	12	10.2	15.5	34.7	60.5	30,956
All machinery	7.7	8	16.3	24.1	47.6	71.7	79,804
Without trade relationships inactive throughout 1993-2006							
FP	8.3	9	..	11.7	44.6	73.4	39,005
P&C	10.3	13	..	5.9	27.3	56.0	27,808
All machinery	9.2	11	..	9.3	37.4	66.2	66,813

Source: Author's calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 3: ***Number of spells during 1993-2006 for exporter-importer-product pairs in intra-East Asian machinery trade***

	Mean	Median	Cumulative percentages (%)				Obs.
			1	2	3	4	
FP	1.9	2	47.0	72.9	90.3	97.8	39,005
P&C	1.7	1	59.2	80.3	93.5	98.8	27,808
All machinery	1.8	1	52.1	76.0	91.6	98.2	66,813

Notes: Active (at least a year during 1993-2006) trade relationships only.
Source: Author's calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 4: ***Length of spells for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006***

	Mean	Median	Cumulative percentages (%)					Obs.
			1	2	4	7	10	
FP	4.3	2	42.9	57.2	69.2	79.6	83.4	74,937
P&C	6.1	3	32.0	44.2	55.5	64.4	69.3	46,823
All machinery	5.0	2	38.7	52.2	63.9	73.8	78.0	121,760

Notes: Active (at least a year during 1993-2006) trade relationships only.
Source: Author's calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 5: ***Estimated Kaplan-Meier survival rates for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006: by product type***

		Estimated K-M survival rate					Number of spells
		1st year	2nd year	4th year	7th year	10th year	
All spells	FP	0.62	0.50	0.39	0.32	0.29	74,937
	P&C	0.72	0.61	0.52	0.47	0.45	46,823
Without 1993-origin spells	FP	0.54	0.38	0.26	0.20	0.18	54,260
	P&C	0.61	0.47	0.35	0.29	0.27	29,264
1-year-gap-adjusted	FP	0.61	0.48	0.39	0.34	0.32	71,822
	P&C	0.71	0.61	0.53	0.49	0.48	44,966
The first spells only	FP	0.64	0.53	0.44	0.35	0.33	39,005
	P&C	0.75	0.66	0.59	0.54	0.52	27,808
Single spells only	FP	0.78	0.74	0.71	0.70	0.70	18,338
	P&C	0.91	0.90	0.88	0.88	0.87	16,458

Notes: The difference of survival function between final products and parts and components for each sample is significant at the 1% level using the log-rank test.
Source: Author's calculation based on the data from UN Comtrade (HS 1992, six-digit).

Table 6: ***Cox proportional hazards estimates for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006: time-invariant covariates only***

	All spells			Without 1993-origin spells			1-year-gap-adjusted		
	All machinery	FP	P&C	All machinery	FP	P&C	All machinery	FP	P&C
Distance (1,000km)	1.054**	1.059**	1.047**	1.036**	1.040**	1.028**	1.055**	1.060**	1.048**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Contiguity dummy	0.999	0.997	1.011	0.981	0.980	0.978	1.002	1.000	1.016
	(0.964)	(0.866)	(0.707)	(0.323)	(0.381)	(0.544)	(0.891)	(0.983)	(0.627)
Language dummy	0.901**	0.893**	0.909**	0.947**	0.935**	0.965	0.902**	0.893**	0.914**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.187)	(0.000)	(0.000)	(0.000)
Log of initial trade value (US$)	0.842**	0.858**	0.807**	0.913**	0.915**	0.903**	0.846**	0.861**	0.813**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subsequent spells dummy	0.680**	0.702**	0.629**	0.624**	0.648**	0.577**	0.785**	0.814**	0.725**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Frequent breaks dummy	2.669**	2.375**	3.341**	1.890**	1.726**	2.276**	2.680**	2.336**	3.494**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P&C dummy	0.684**			0.772**			0.692**		
	(0.000)			(0.000)			(0.000)		
Observations	121,760	74,937	46,823	83,524	54,260	29,264	116,788	71,822	44,966
Number of spells	121,760	74,937	46,823	83,524	54,260	29,264	116,788	71,822	44,966
Number of failures	74,294	49,603	24,691	58,670	39,308	19,362	69,322	46,488	22,834
Log likelihood	-733,027	-466,985	-218,596	-563,530	-361,286	-165,221	-683,802	-437,864	-201,781

Notes: The sample and the trade relationships of interest are listed at the top of each column and the covariates are in the first left column. Coefficients are expressed as hazard ratios. P-values are in parentheses. ** and * indicate significance at the 1% and 5% level. All regressions include exporter and importer fixed effects, but those coefficient estimates are not reported for brevity. The estimates are stratified by machinery subsectors. Multiple spells of respective exporter-importer-product pairs are treated as independent. Trade data are in constant 2000 U.S. dollars.

Table 7: ***Cox proportional hazards estimates for bilateral trade relationships at the product-line level in intra-East Asian machinery trade during 1993-2006: with time-dependent covariates***

	All spells						
	Benchmark			AFTA impacts			
	All machinery	FP	P&C	All machinery		FP	P&C
Distance (1,000km)	1.084**	1.085**	1.082**	1.087**	1.088**	1.089**	1.083**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Contiguity dummy	0.918**	0.922**	0.923**	0.917**	0.917**	0.920**	0.923**
	(0.000)	(0.000)	(0.008)	(0.000)	(0.000)	(0.000)	(0.008)
Language dummy	0.875**	0.869**	0.885**	0.876**	0.876**	0.869**	0.885**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exporter's GDP (100bil US$)	0.917**	0.915**	0.920**	0.917**	0.906**	0.904**	0.909**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Importer's GDP (100bil US$)	0.981**	0.982**	0.979**	0.981**	0.969**	0.970**	0.965**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Exporter's credit rating (10 points)	0.971**	0.967**	0.978	0.971**	0.964**	0.960**	0.971*
	(0.000)	(0.001)	(0.093)	(0.000)	(0.000)	(0.000)	(0.028)
Importer's credit rating (10 points)	1.031**	1.029**	1.032*	1.031**	1.026**	1.025**	1.027*
	(0.000)	(0.001)	(0.015)	(0.000)	(0.000)	(0.007)	(0.034)
Number of potential suppliers	0.955**	0.958**	0.950**	0.955**	0.955**	0.958**	0.950**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Abs. difference in PCGDP (1,000 US$)	0.995**	0.996**	0.993**	0.995**	0.995**	0.995**	0.993**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
%change in RER (10%)	0.989**	0.986**	0.995	0.989**	0.989**	0.987**	0.995
	(0.003)	(0.003)	(0.424)	(0.003)	(0.003)	(0.003)	(0.382)
AFTA dummy				1.023			
				(0.343)			
AFTA dummy (before year 2002)					1.110**	1.114**	1.084
					(0.000)	(0.000)	(0.057)
AFTA dummy (in and after 2002)					0.858**	0.859**	0.829**
					(0.000)	(0.000)	(0.000)
Log of initial trade value (US$)	0.878**	0.890**	0.851**	0.878**	0.878**	0.890**	0.851**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subsequent spells dummy	0.497**	0.512**	0.468**	0.497**	0.503**	0.519**	0.474**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Frequent breaks dummy	2.945**	2.696**	3.431**	2.945**	2.933**	2.685**	3.420**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P&C dummy	0.803**			0.803**	0.803**		
	(0.000)			(0.000)	(0.000)		
Observations	611,400	325,218	286,182	611,400	611,400	325,218	286,182
Number of spells	121,760	74,937	46,823	121,760	121,760	74,937	46,823
Number of failures	74,294	49,603	24,691	74,294	74,294	49,603	24,691
Log likelihood	-721,692	-459,975	-214,529	-721,692	-721,594	-459,908	-214,494

Notes: The sample and the trade relationships of interest are listed at the top of each column and the covariates are in the first left column. Coefficients are expressed as hazard ratios. P-values are in parentheses. ** and * indicate significance at the 1% and 5% level. All regressions include exporter, importer, and year fixed effects, but those coefficient estimates are not reported for brevity. The estimates are stratified by machinery subsectors. Multiple spells of respective exporter-importer-product pairs are treated as independent. Trade data and GDP data are in constant 2000 U.S. dollars.

Table 8: ***Robustness check for the Cox proportional hazards estimates with time-dependent covariates***

	Without 1993-origin spells			1-year-gap-adjusted			The first spells only			Single spells only		
	All machinery	FP	P&C	All machinery	FP	P&C	All machinery	FP	P&C	All machinery	FP	P&C
Distance	1.074**	1.076**	1.070**	1.089**	1.090**	1.086**	1.090**	1.092**	1.084**	1.168**	1.171**	1.163**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Contiguity dummy	0.904**	0.903**	0.911**	0.915**	0.916**	0.925*	0.945*	0.962	0.916*	1.145*	1.132*	1.166
	(0.000)	(0.000)	(0.009)	(0.000)	(0.000)	(0.014)	(0.010)	(0.143)	(0.028)	(0.011)	(0.044)	(0.158)
Language dummy	0.912**	0.901**	0.926**	0.873**	0.862**	0.891**	0.838**	0.825**	0.861**	0.834**	0.827**	0.794**
	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.008)
Exporter's GDP	0.874**	0.873**	0.874**	0.922**	0.920**	0.926**	0.954**	0.952**	0.950**	1.044**	1.030*	1.110**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.025)	(0.000)
Importer's GDP	0.955**	0.954**	0.957**	0.985**	0.985**	0.984**	0.981**	0.984**	0.972**	0.984	0.979*	0.984
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.000)	(0.009)	(0.001)	(0.064)	(0.042)	(0.351)
Exporter's credit rating	0.955**	0.951**	0.963*	0.965**	0.961**	0.973*	0.985	0.990	0.988	0.940**	0.960	0.932
	(0.000)	(0.000)	(0.013)	(0.000)	(0.000)	(0.044)	(0.175)	(0.492)	(0.487)	(0.009)	(0.147)	(0.118)
Importer's credit rating	1.019*	1.012	1.031*	1.031**	1.029**	1.032*	1.042**	1.033*	1.059**	1.037	1.007	1.106*
	(0.037)	(0.285)	(0.044)	(0.000)	(0.002)	(0.018)	(0.000)	(0.011)	(0.002)	(0.129)	(0.814)	(0.033)
Number of potential suppliers	0.959**	0.960**	0.957**	0.951**	0.953**	0.948**	0.950**	0.956**	0.941**	0.930**	0.936**	0.917**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Abs. difference in PCGDP	0.994**	0.995**	0.993**	0.994**	0.995**	0.993**	0.995**	0.996**	0.992**	0.991**	0.993**	0.986**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
%change in RER	0.993	0.989*	1.000	0.995	0.992	1.004	0.981**	0.976**	0.990	1.010	1.002	1.022
	(0.087)	(0.042)	(0.951)	(0.244)	(0.077)	(0.594)	(0.000)	(0.000)	(0.200)	(0.403)	(0.912)	(0.347)
Log of initial trade value	0.922**	0.927**	0.911**	0.881**	0.893**	0.856**	0.832**	0.850**	0.795**	0.862**	0.873**	0.832**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Subsequent spells dummy	0.639**	0.675**	0.573**	0.565**	0.585**	0.528**						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
Frequent breaks dummy	2.080**	1.908**	2.449**	3.052**	2.751**	3.674**						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
P&C dummy	0.847**			0.817**			0.745**			0.686**		
	(0.000)			(0.000)			(0.000)			(0.000)		
Observations	233,342	138,116	95,226	616,372	328,333	288,039	455,177	230,036	225,141	369,448	173,711	195,737
Number of spells	83,524	54,260	29,264	116,788	71,822	44,966	66,813	39,005	27,808	34,796	18,338	16,458
Number of failures	58,670	39,308	19,362	69,322	46,488	22,834	40,118	26,495	13,623	8,101	5,828	2,273
Log likelihood	-557,199	-357,176	-163,019	-672,785	-430,971	-197,911	-366,735	-229,419	-111,503	-64,152	-43,775	-15,385

Notes: See notes of Table 7.