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Structural determinants of global trade in graphic paper and pulp products

Abstract

Both trade and production of graphic paper have decreased over the last three decades. While this general decrease can partially be attributed to increased prominence of information technology, the overall figure is devoid of context and thus of most of its meaning to global economy. In this study we aim to break this trend down across the geographical and temporal scope, across its supply-chain commodities and to find out what drives the global trade patterns. Econometric trade models focus on the trading countries and direct exports or imports but fail to consider the structural and the indirect trade relations. We take the approach of network analysis, where the emphasis is on the structure of trade and not on country-level descriptors.

We focus on 1995-2017 period as within it this decrease can be observed and assess the entire graphic paper and pulp supply chain, consisting out of printing and writing paper, mechanical wood pulp, chemical wood pulp, semichemical wood pulp, pulp made from fiber other than wood, recovered paper and paperboard. We employ descriptive statistical and network analysis, grouping and role analysis, and end with an inferential logistic regression quadratic assignment procedure model.

Results show that newsprint trade decline is mirrored in printing and writing paper and mechanical wood pulp. The trade network densities have remained generally stable throughout the observed period, but the topological proprieties of the individual product groups vary greatly. Although no stabile grouping of countries throughout the assessed period could be observed, role analysis shows that countries tend to trade within their continent, that European countries are at the core of the trade network, and that the structural shift of decline of the trade value is followed by increasing prominence of several Asian countries, such as China and Indonesia. The most important finding of the study is that internal trade effects such as reciprocity and transitivity are much more explanatory than classical effects used in trade models such as GDP per capita, geographical distance or forest endowment.

Key words: International trade, network analysis, supply chain, modelling, graphic paper, pulp

Introduction

Total value of international trade of forest products in the world is 373 billion $USD (FAO, 2017). The main types of forest products are roundwood, sawnwood, wood-based panels, pulp, and paper and paperboard. Globally, approximately 3.9 billion m^3 of roundwood are produced, over half of which are used as raw material for producing sawnwood, panels and pulp and paper products and the rest is used for energy production (FAO, 2019). Paper products can be classified into three categories according to their use: graphic paper (newsprint, printing and writing paper), paperboard and sanitary paper. The production for graphic paper experienced a slight increase from 116 million tonnes to 153 million tonnes between 1995 and 2007, and then affected by the financial crisis, declined to 135 million tonnes in 2009 (FAO, 2019). Following small increase in 2010, it never bounced back and reached 110 million tonnes in 2019 (FAO, 2019).

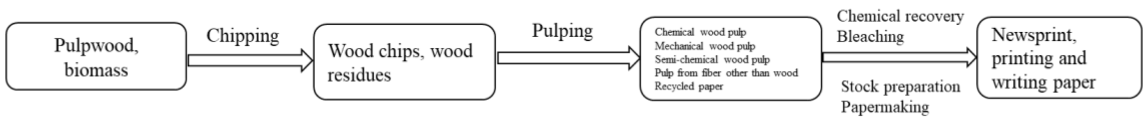


Figure 1. The production process of graphic paper products

The production of graphic paper is illustrated in Figure 1. First, raw material including wood chips (chipped from pulpwood) and wood residues (produced from biomass) is prepared for pulping process. Second, chips and wood residues are made into pulp. Pulping process can be divided into four categories, which are chemical pulping, mechanical pulping, semi-chemical pulping, and recycled paper pulping. This is followed by chemical recovery, bleaching, stock preparation and papermaking (Bajpai, 2015).

Several studies have already pointed out structural changes in the paper and pulp market (Hetemäki *et al*, 2013; Latta *et al*, 2016; Pätäri *et al*, 2016). Not merely due to the financial crisis, people's demand for graphic paper is also decreasing (Ochuodho *et al*, 2017). With the emergence of information technology, people's lifestyles are changing, and the use of digital media is increasing. Digital media has a substitution impact on the graphic paper products, especially newsprint (Rougieux, 2017). Apart from the changes in the paper consumption, there are also changes in paper production. Due to long-time economic turndown and increasing production cost, the production capacity of paper and paperboard has moved from West to East (Hetemäki and Hurmekoski, 2016). Besides that, the real price of the graphic paper is decreasing, and the paper consumption and production are also declining in the OECD countries (Hetemäki *et al*, 2013). Policy changes also drive Paper and Pulp Industry (PPI) to make changes. The European Union has set a goal to reducing carbon emissions to 40% below 1990's level by 2030, and to achieve this goal, PPI transfers to bioeconomy by applying new green innovations (Pätäri *et al*, 2016). Above factors have different effect on graphic paper products. Under the effect of the internet adoption, the demand for newsprint declines in all regions, while the demand for writing and printing paper is not largely influenced by internet usages. Due to different production and trade patterns (Latta *et al*, 2016), graphic paper products are classified into these two groups.

There have been many publications studying trade and production of forest products, which also look at how the production and consumption of paper products will change in the

future (Hetemäki, 2014; Latta *et al*, 2016; Larson *et al*, 2018; Ochuodho *et al*, 2017, Johnston, 2016; Hetemäki *et al*, 2013; Poyry, 2015). Another set of literatures focuses on causality between trade and production of forest products. They use classical economic models or create new econometric models (Rougieux, 2017; Ochuodho, Withey and Johnston, 2017; Latta *et al*, 2016; Chiba *et al*, 2017). By applying classical trade models, Uusivuori (2002) lists forest endowment and economic activity as key factors affecting international trade in forest products. Lundmark (2010) also specifies energy policy and country specific characteristics as important factors. From the study by Solberg and Moiseyev (1997), the drivers affecting forest trade and production are identified as population development, economic growth, price and price expectations, technology, institutional and political frame condition. In this paper, we look how these factors influence graphic paper and pulp trade flow changes.
Classical production and trade models (Moiseyev *et al*, 2004; Northway *et al*, 2013; Buongiorno and Zhu, 2017) focus on countries as the main unit of analysis, where both the independent and dependent variables under study are predominantly assigned to countries. This kind of focus enables modelers to provide valid country-level insights, but also constraints them from seeing 'the big picture'. For example, country-level production and direct bilateral trade flows fail to describe interconnected global trade and production networks since their dynamic are governed by indirect and complex interdependencies to a large extent and many of which are only being recognized in the last thirty years (Barabási, 2002). Many of these interdependencies are for now confined to formal mathematical expressions, lacking standardized vocabularies (e.g. Fagiolo *et al*, 2010; Barigozzi *et al*, 2010). However, they are adequate for explaining many important developments in global trade, such as structural inequality and globalization (Smith and White, 1992; Mahtuga, 2006; Yang *et al*, 2015), or financial integration (Schiavo *et al*, 2010) and stability (Nier *et al*, 2007). Some, on the other hand, may have simple intuitive meaning – like the economic complexity index (Hidalgo and Hausmann, 2009), a highly explanatory (Hausmann *et al*, 2013) holistic productive capability measure for large economic systems. Many of the problems associated with gravity model can be successfully tackled in equivalent network models, e.g. stochastic actor-based models for network dynamics (Snijders *et al*, 2010) or co-evolution models of network and behavior (Steglich *et al*, 2010). These problems (Kabir *et al*, 2017) refer to zero trade value flows, relations between trade flows and both time-variant and time-invariant variables, interaction effects between time-variant and time-invariant variables, controlling for multi-collinearity and especially problems that are in econometric trade literatures labelled as endogeneity problems (i.e. 'errors' in the estimation due to internal structure of the data). These endogenous 'problems' are actually the focus of the network analysis, and the gravity models have also started to tackle them, for example through reciprocity (Harris *et al*, 2012). Reciprocity is perhaps the basic feature of network analysis and is used as a default variable in all major network models, both in the two previously mentioned ones, in the exponential random graph models (Lusher *et al*, 2013) and in the LRQAP.

In this paper we take this approach of focusing on the graphic paper trade structure, i.e. a network analysis approach, which draws insights both from natural and social sciences. Networks consists out of nodes (here countries) and ties (here trade flows). Its basic unit of analysis is the tie, and the main conceptual premise is that the indirect relations (i.e. the structure of the trade network) is at least explanatory of the variability in the data as are the direct ties and the attributes of nodes. Mathematically rooted in graph theory, it has almost independently evolved through two distinct schools of thought (one rooted in mathematical sociology and another one in physics) where these two groups are only recently starting to define shared theoretical understandings, vocabulary, and methodological interpretations (Scott and Carrington, 2011; Hidalgo, 2016). This study describes the longitudinal changes of the global trade network in graphic paper products. First, we use statistical analysis to detect changes in graphic paper and pulp trade value from 1995 to 2017. Then, descriptive network analysis is used to identify the topological properties of the whole network, including density, reciprocity, number of trade flows and trading countries. After that, different procedures of SNA are applied to identify the importance of key countries, potential grouping of countries and individual countries' positions. And last, we explore factors affecting the production and trade of the graphic paper products and create a model of newsprint product trade by applying logistic regression quadratic assignment procedure (LRQAP; Borgatti *et al*, 2013).

Materials and methods

Graphic paper and pulp products cover (I) newsprint, (II) printing and writing paper, (III) mechanical wood pulp, (IV) chemical wood pulp, (V) semichemical wood pulp, (VI) pulp made from fiber other than wood, and (VII) recovered paper and paperboard. Data used for analysis is extracted from BACI trade database (Gaulier and Zignago, 2010), which is based on the reported data in the UN ComTrade database. The database hosts single value per trade flow in 1000$USD. Time series data in 1995-2017 period is used. Harmonized Commodity Description and Coding System 1992 is used on levels of six-digit codes (HS6) where a total of 35 codes have been grouped into above stated seven categories (see Appendix B). All trade values are expressed as 2017 constant values according to global inflation rates from the World Economic Outlook (2019). Main data organization is adjacency matrix, where all countries are listed symmetrically as rows and columns, and where row-entries are exports and column-entries are imports. Adjacency matrix data format is subsequently used as basis for explanation of applied network procedures. Next step was to break-up the 1995-2017 period into several discrete sub-periods, where the objective is that the overall trade by product group is similar within the sub-period but dissimilar across sub-periods. This was done by applying Quadratic Assignment Procedure (QAP) on all adjacency matrices belonging to individual product groups. Multidimensional Scaling (MDS) was used to visualize (see Supplementary Material) this correlation matrix, where the proximity between years reflects their similarity in global trade. Based on this procedure, we split the data in four periods: (I) 1995, (II) 1996-2000, (III) 2001-2008 and (IV) 2009-2017. We have selected 1995, 1998, 2005 and 2017 as the years representing these four periods, where 2017 was selected over 2013 (central year of the fourth period) to prolong the time series.

The study is divided in three phases: (I) descriptive analysis, (II) group and roles, and (III) inferential analysis (see Figure 2). As stated in the introduction, many of the applied network procedure don't have standardized interpretation within the context of international trade; thus, we contextualize them as based on their non-technical description.

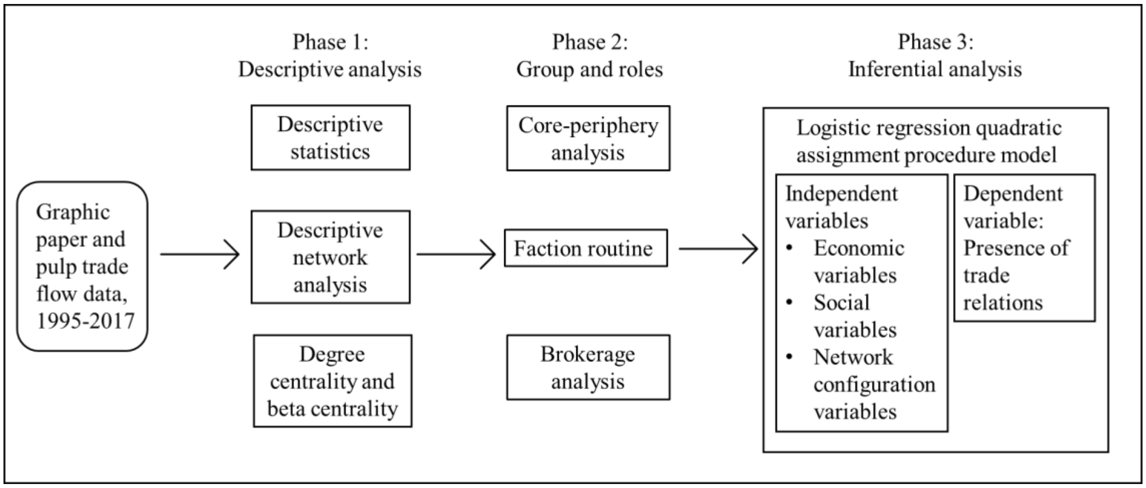


Figure 2.Methodology Overview

Descriptive analysis looks at changes in global trade value by year and product group, trade share (i.e. density) and reciprocity. Beta centralities can explain exports (outdegree), imports (indegree) and structural trade effects that individual countries have. Positive (+) beta centrality means a country trades with many partners that are strongly trading with other countries themselves, while negative (-) beta centrality means it trades with countries that are weakly trading themselves. Having high beta+ centrality can be interpreted as being central in the overall trade network, while having high beta- centrality can be interpreted as having high 'bargaining' power as country's trading partners do not have alternative trading channels. When ordered by their total value of exports and imports in decreasing ordered, top 50 countries account for more than 90% of global trade value in each of the assessed commodity groups. This is true for entire 1995-2017 period. We opted to utilize the entire trade network in its descriptive statistical representation and only the network of top 50 trading countries in all subsequent network procedures as such truncated version simplifies the interpretation of its structure without major validity loss.

Group, roles, and inferential analysis are conducted on binary data, except categorical core-periphery analysis, i.e. the continuous value of trade flow has been dichotomized to 1 (there is a trade flow) and 0 (there is no trade flow). Median and mean trade flow values have been selected as cutoff values, and where appropriate, separated by product group, year, and region. Categorical core-periphery method is used to check the pattern within the network and it uses a measure of fit which depend on the correlation between adjacency matrix and idealized block model (Borgatti *et al*, 2013), where the level of correlation between the two reflects to which extent does the network structure fit to the idealized block model. The procedure splits the nodes (i.e. countries) of the network into two groups; the first one (core) where nodes are interconnected (i.e. trade) with one another and the second one (periphery) whose' nodes are not interconnected with one another nor are interconnected with the core. The correlation score tells us how close the observed network structure is 'close' to this ideal type. Faction routine is a method which can identify substructure from networks by permuting adjacency matrix. It aims to find the optimal arrangement of nodes into factions to imitate the ideal cohesive subgroup structure, which is the one maximizes internal cohesion within groups and separation between groups (Borgatti *et al*, 2013). In sum, faction routine tries to identify multiple groups of countries that strongly trade within the group but not out of it – opposite of what the core-periphery analysis does. Brokerage analysis groups (Gould and Fernandez, 1989) attributes roles to countries based on their trade patterns and a single characteristic. The selected characteristic is a continent in which a country is located (or region in case of Oceania), i.e. Africa (AF), Antarctica (AN), Asia (AS), Europe (EU), North America (NA), Oceania (OC) and South America (SA). The brokerage roles played by a node can be coordinator (trades within its continent), consultant (imports from and exports to the same but not its own continent), gatekeeper (imports from another continent but exports within its own), representative (imports from its own and exports to another continent) and liaison (trades with different continents). Relative brokerage scores are raw scores divided by randomization expected values given group sizes. Randomization expected values are calculated by the number of relations for each type that would be expected by pure random processes (Hanneman and Riddle, 2005). Group size, in this context, means the number of trading countries in each continent. Direct comparison of these brokerage scores across years can be made as it is applied on the networks with same membership. The brokerage roles by country have been then summed-up on a continental level, and each one of them is marked with one dominant brokerage role.

In the context of network analysis, Quadratic Assignment Procedure (QAP; Krackhardt, 1988) is frequently used to test the correlation between matrices (Borgatti *et al*, 2013). Logistic-Regression QAP (LR-QAP) is its extension used to assess the relation between a dichotomized matrix-type dependent variable (i.e. trade) and a series of independent variables. These independent variables can be exogeneous vectors (e.g. descriptors of countries such as GDP per capita) and matrices (e.g. bilateral trade agreements or geographical distance between countries) and endogenous effects (e.g. reciprocity and transitivity of trade relations). The latter is important to the formation of patterns of ties at global network level and it captures dyadic dependent processes (Pinheiro *et al*, 2016). For example, transitivity reveals that triads with two ties tend to generate the third tie (Lee and Bai, 2013), e.g. if country *A* exports to *B* and *B* exports to *C*, then *A* will export to *C*. Preferential attachment implies that a new node is more likely to form a tie with another node because of its centrality (Maoz, 2012). Reciprocity entails mutual ties promote transportation process. First, the rows and the columns in the trade matrices are randomly permuted multiple times to conduct the regression analysis and stabilize p value (Borgatti, *et al*, 2013). Then, R^2 and coefficient can be obtained, and multiple regression model is formed. A trade flow matrix is regressed on two or more matrices representing factors affecting trade and production. Thus, we generate the share of variance in the trade network that can be explained by the model – all of which can be interpreted same as in a classical multiple regression model. The details of independent variables applied in our LR-QAP model are presented in Table 1 and they are identified from previous publications. For example, Fontagné *et al* (2011) have found that most explanatory variables are bilateral distance, contiguity, colonial relationship, common language, and tariffs. Head and Mayer (2014) used engagement in free trade agreement as independent variable in their model. Both Rougieux (2017) and Latta *et al* (2016) reported that increased internet penetration rate has led to the reduction in newsprint paper demand. Lundmark (2010) pointed out that forest endowment has positive relationship with trade value, and it is represented by harvested volume of roundwood in his paper. Pinheiro *et al* (2016) chose network configurations to specify the model, and they believe global patterns in the networks emerge from individual decisions.

Type	Factors	Description	Source	Justification
Control variables	Contiguity	1: common border 0: no common border	CEPII GeoDist Dataset (Mayer &Zignago, 2011)	Border effect. countries sharing common border are easier to trade with each other.
	Weighted bilateral distance	Weighted bilateral distance between origin and destination country in kilometer (population weighted).	CEPII GeoDist Dataset	Weighted bilateral distance may be a proxy to trade cost. If the distance is larger, the trade cost is higher.
	Language similarity	1: if language spoken by at least 9% of the population in both countries. 0: otherwise	CEPII GeoDist Dataset	People who speak the same language are easier to trade with each other and reduce trade barrier to some extent.
	Colonial links	1: if exporter and importer country ever in colonial relationship. 0: otherwise	CEPII GeoDist Dataset	Similar history may indicate there are some business networks existing in both countries.
	Engagement in free trade agreement	1: if there is free trade agreement existing between exporter and importer countries. 0: otherwise	The CEPII Gravity Database (Head& Mayer, 2014)	Reduction in trade barriers can facilitate trade flow.
Atrribute-effect explantary variables	Forest area (%of land area)	Absolute difference in proportion of forest area account for total land area (%) between exporter and importer countries.	World Bank(2020)	Forest endowment is an important determinant in the paper by (Lundmark, 2010).
	Individuals using the Internet (% of population)	Absolute difference in internet adoption rate between exporter and importer countries.	World Bank(2020)	Increasing internet adoption rate show some substitution effect on graphic paper products.
	Economic output	Absolute difference in GDP per capita, ppp (current 2017 US dollar) between exporter and importer country	World Bank(2020)	GDP per capita shows the degree of economic development and people's living standard.
Relational-effect explantary variable	Reciprocity	The extent to which ties are reciprocated between a dyad.		Reciprocity reveals the possibility of trading countries to reciprocate trade relations and becoming mutual in the international trade.
	Transitivity	The extent to which triples are present in the networks.		Transitivity indicates the likelihood of social structure in the trade networks arise about triads (Borgatti, Everett & Johnson, 2013).
	Preferential attachment	The extent to which a node is more likely to be more popular due to its centrality (Mascia et al., 2020).		Preferential attachment indicates the likelihood of trading countries are likely to trade with others depending on their popularity (Mascia et al., 2020).

Table 1.Independent variables and their description

Results

Descriptive Results

The trade value of newsprint, Printing and Writing paper (P&W) and of mechanical wood pulp has decreased from 1995 to 2017 (from 31.1 to 9.2 bil. USD, from 78.5 bil. to 29.0 bil., and from 1.7 to 0.3 bil. USD, respectively; see Figures 3-5). It can be seen from Appendix C that trade value of other product groups remained steady in the same period.

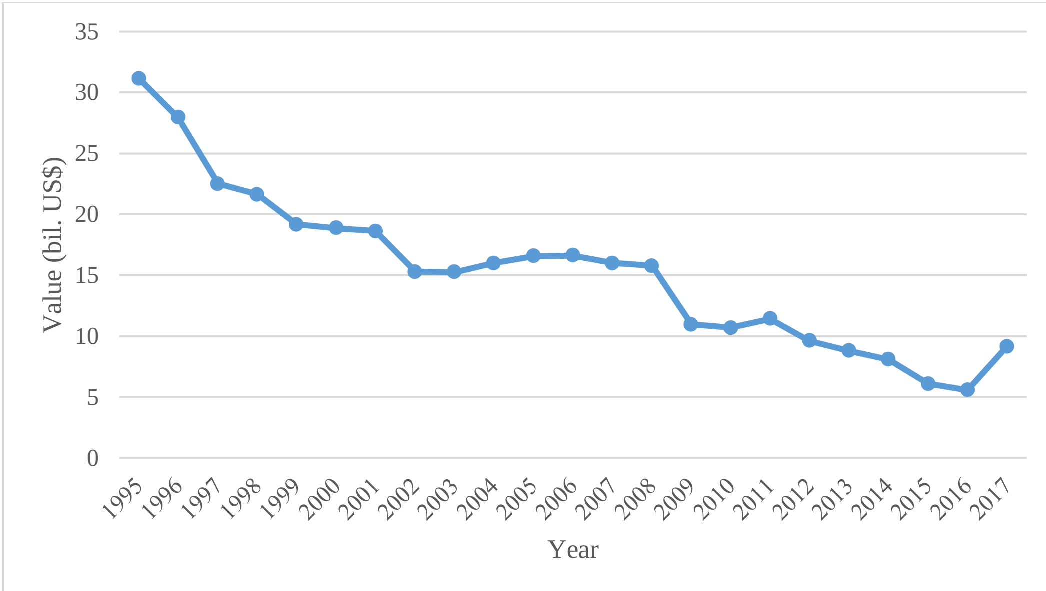


Figure 3.Value of newsprint trade, 1995-2017

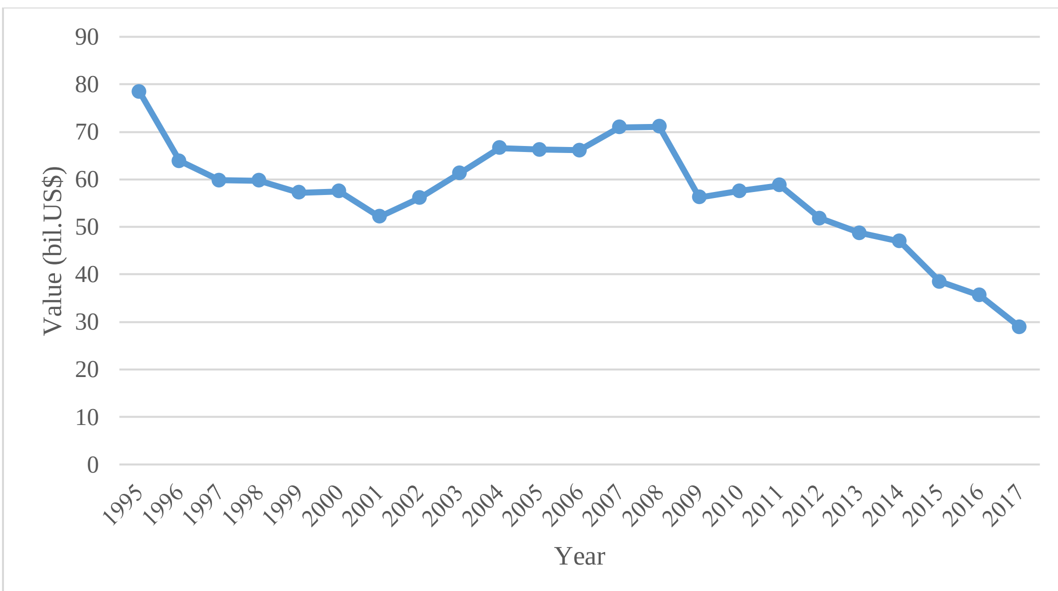


Figure 4.Value of printing and writing trade, 1995-2017

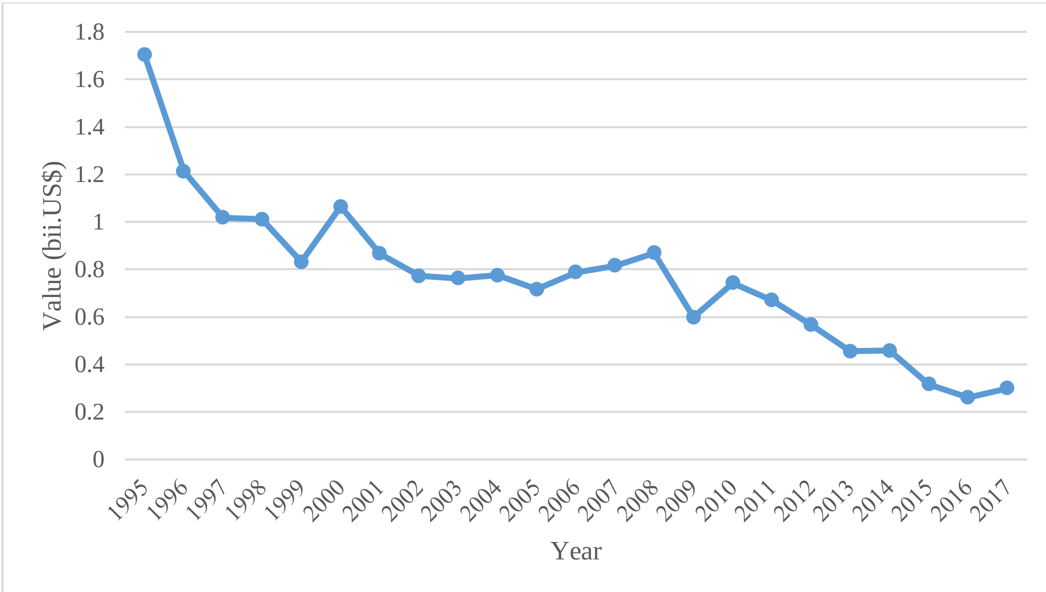


Figure 5. Value of mechanical wood pulp trade, 1995-2017

The binary density (share of existing trade flows from all possible ones) of graphic paper and pulp products varies from 0.035 to 0.120, which reveals that trade networks of graphic paper and pulp are very sparse (see Supplementary Material). Except for mechanical wood pulp (from 0.045 to 0.036 between 1995 and 2017), the other 6 products show an increasing trend in network density in the same period (Figure 6).

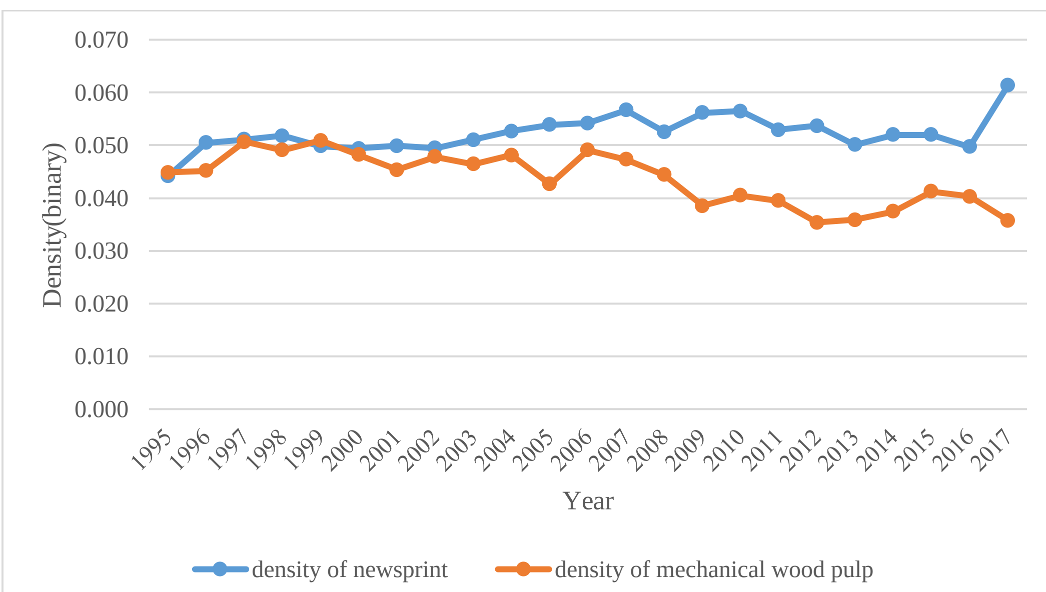


Figure 6. Density(binary) of newsprint and mechanical wood pulp trade, 1995-2017

Basic topological structure of the observed trade networks is presented in Table 2. Number of trading countries in graphic paper and pulp products increases between 1995 and 2017, except for chemical wood pulp. P&W trade has 214 trading countries and 4948 trade flows on average, while semichemical wood pulp trade only has 87 countries and 307 trade flows.

Recovered paper trade has the highest average dyadic reciprocity among all the product groups, which is 0.249.

Trade network by product groups	No. of trading countries	No. of trade flow	Maximum no. of possible trade flow	Dyadic reciprocity	Density(binary)
newsprint	189	1854	35417	0.140	0.052
printing and writing paper	214	4948	45600	0.244	0.108
mechanical wood pulp	93	373	8665	0.125	0.044
chemical wood pulp	155	1474	23755	0.212	0.062
semichemical wood pulp	87	307	7496	0.084	0.041
pulp from fiber other than wood	131	771	17248	0.209	0.045
recovered paper and paperboard	180	1718	32275	0.249	0.053

Table 2.Topological metrics for trade networks by product groups, 1995-2017

Looking at all product groups together, top trading countries are roughly concentrated on Europe and North America. However, some Asian countries, especially Japan and China emerge as top countries in global trade. For newsprint products, USA and Canada dominate the market. Canada constitutes 20.8% of global newsprint trade value and USA accounts for 17.9% of global newsprint trade value during the period of 1995-2017. Canada mainly acts as exporter and around 99.3% of its newsprint trade value is export value. USA behaves as importer and approximately 85.8% of its total trade value consists of import trade. Canada's normalized Beta+ centrality score for export is 1 and it reveals that Canada exports to strong exporters (see Supplementary Material). The normalized Beta+ centrality scores for import of USA is 1 and it shows that USA imports from strong importers rather than producers. Germany and USA are the main countries in the printing and writing paper trade. Germany accounts for 11.9% of global printing and writing paper trade. Germany is both exporter and importer, where 55.1% of its trade value belongs to exports and 44.9% belongs to imports. USA constitutes 9.3% of global trade. China emerges as top country in semichemical wood pulp and recovered paper and paperboard trade, and it accounts for 14.4% and 17.8% of global trade, respectively. China is strongly dependent on semichemical wood pulp import and its share for import is more than 99%. Its normalized Beta+ centrality scores for import is very high and that reveals that it imports the products from countries that are also strong importers. Shown in the Supplementary Material are full results on imports, exports, and beta centrality. To sum up, China tends to trade graphic paper and pulp products with other countries which have many connections themselves.

Groups and Roles

Only 14 out of 50 countries have core membership and the rest are periphery members. For all product groups, Canada, USA, and EU countries remain core members among top 50 trading countries across the four observed years, which reveals that developed countries still dominate in graphic paper and pulp trade (see Supplementary Material). Taken newsprint trade as an example, core-periphery partition in newsprint trade does not change in these 4 years. Canada and USA are central all along, while the other countries are periphery members. However, we can also see new emerging countries, such as China, Japan, and Philippines. For semichemical and chemical wood pulp products, it is noticeable that China becomes the core country of chemical wood pulp trade in 2017. For pulp from fiber other than wood trade, Asian countries, like Japan, China, and Philippines become core member in 2005 and 2017. To sum up, all above indicates structural shift in graphic paper and pulp industry, and trade emphasis is starting to move to Asian countries.

The following procedures are conducted on the networks dichotomized on the mean and median trade flow values. Table 3 shows these values for selected years, where in general mean values are much greater than the medians. This divergence in cutoff values produces equivalent divergence in network structures that they produce – i.e., the networks based on median have lower density (share of possible trade flows), smaller number of ties (trade flows) and higher number of isolates (countries with no trade flows) than the networks based on mean cutoff value.

	newsprint				printing and writing paper				mechanical wood pulp			
	1995	1998	2005	2017	1995	1998	2005	2017	1995	1998	2005	2017
Mean (US$1000)	38114.78	25917.91	18480.11	7090.53	48961.26	34472.76	33553.54	14697.22	5882.96	3529.66	2279.69	1131.71
Median (US$1000)	1512.5	1055	963.5	275.5	3113	1817.5	2355	1144	349	211	105	70.5

	chemical wood pulp				semichemical wood pulp				pulp from fiber other than wood				recovered paper and paperboard			
	1995	1998	2005	2017	1995	1998	2005	2017	1995	1998	2005	2017	1995	1998	2005	2017
Mean (US$1000)	65336.13	33207.29	34020.46	37830.43	8242.76	4678.91	6441.67	7415.1	2626.24	1830.72	1807.51	1267.07	15051.52	5518.36	8934.93	10583.23
Median (US$1000)	4309	2456.5	1858	2133	450.5	255	358.5	202	332	145	147.5	73	505	218.5	234	305

Table 3.Mean and median value of top 50 countries' trade value by product groups, 1995-2017

For all product groups, countries are more likely to trade with others within the same faction. Taken mechanical wood pulp trade in 1995 as an example, there are in total 4 factions, and the binary density within faction 1 is 0.65, while the binary density between faction 1 and 2 is 0.067 (see Supplementary Material). It can be seen from the Figure 7 that the node size (reflecting value of trade) of Canada and USA is pronounced among all the core countries, while the node sizes of other countries are relatively small. In summary, we find more stabile faction patterns by focusing on top 50 countries, but the variability of faction membership across time and product groups is still too great to make simple and intuitively meaningful interpretation of country grouping.

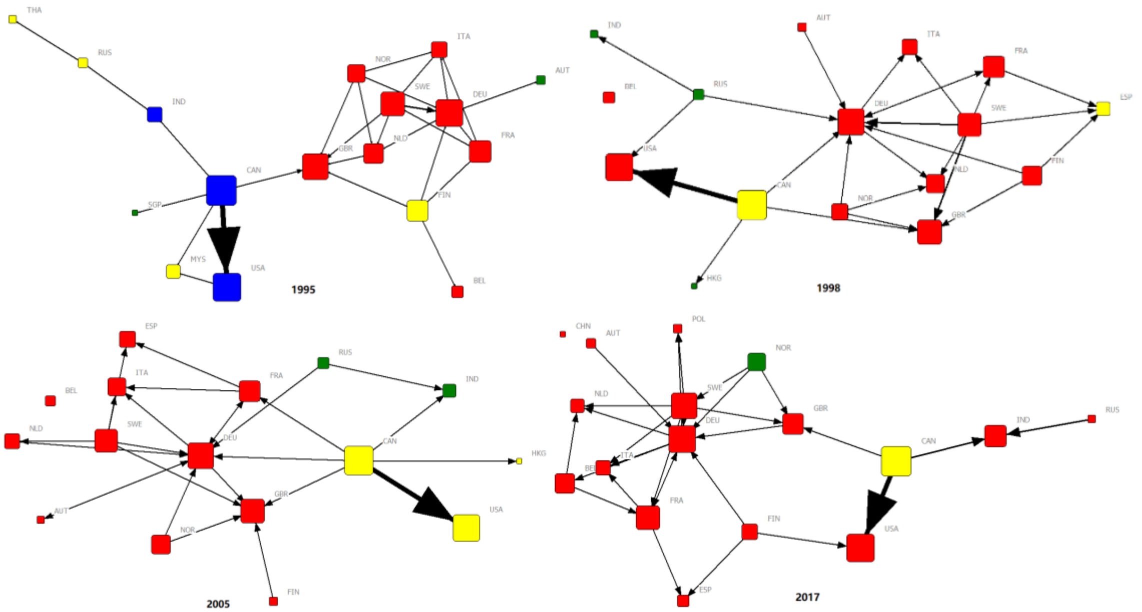


Figure 7. The main trade relations (top 10% trade flows) within key years within the core countries in newsprint trade, 1995-2017, nodes represent trading countries, country node is scaled according to trade value, ISO3 country code is shown on the right of the node, different colors stand for different factions, and ties are scaled according to their trade value.

Figure 7 shows that factions in newsprint trade roughly corresponds to continents. Taken newsprint trade in 1995 as an example, most of European countries fall into the same faction, except Austria. Canada and USA tend to belong to the same faction. In 1998, Asian countries, such as India and Hongkong are identified in the same faction. In general, newsprint trade networks are quite stabile along 23 years; except for in 2017, when China become core country and stayed with EU countries and USA in the same faction. It reveals that China plays more important role in 2017 networks and has close trade relations with EU and USA than before. This trend is even more pronounced in other product groups, closer to the beginning of the supply chain. All above reveals that there is structural shift occurred after 2005 and that trade relations between Asian and developed countries are getting closer; but that Europe, especially Germany, is the key element of the trade network.

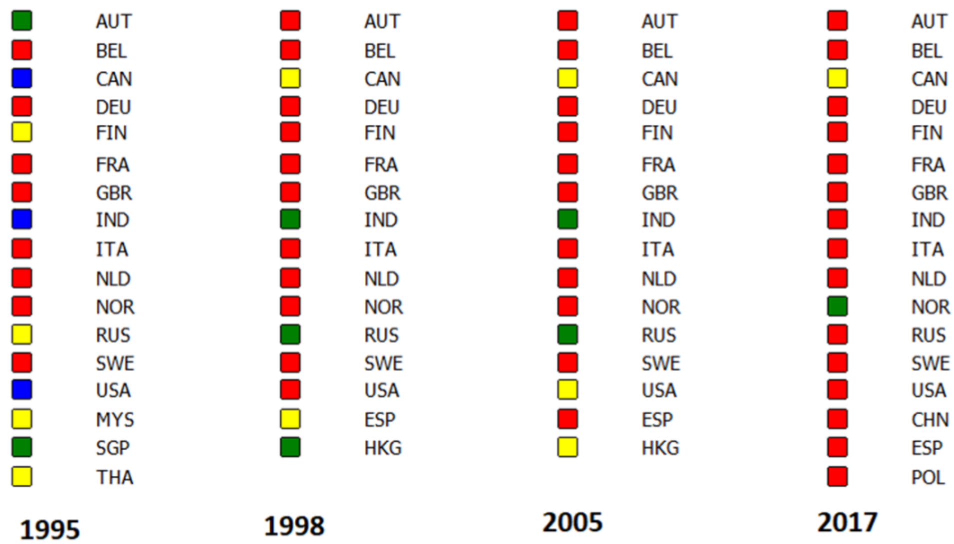
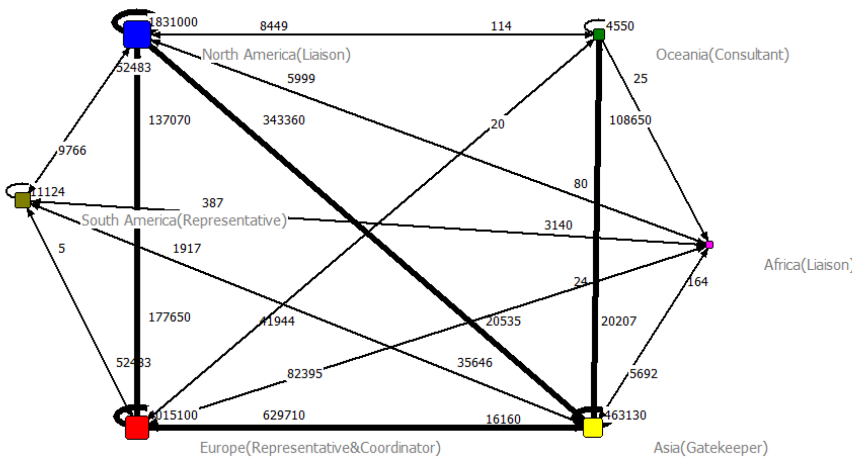


Figure 8.Image graph of faction partition of top 50 trading countries in newsprint, 1995-2017, one column represents core countries in one year. In column, nodes represent trading countries, ISO3 country code is shown on the right of the node and colors represent faction association (i.e. same trading group)

For the P&W trade, majority of countries belong to the same faction, and only one or two Asian countries are identified as a unique faction (see Supplementary Material). Figure 8 shows that Asian and Eastern European countries play an important role since 2005. South American countries, such as Brazil and Chile play an important role in chemical pulp trade during the observed period.

Full brokerage analysis (see Supplementary Material) shows that countries of the same continent are likely to play the same broker role in graphic paper and pulp trade. Its graphical summary is presented in Figure 9, and the role that each continent plays remains unchanged for year 1995, 1998, 2005 and 2017. European countries tend to play "coordinator" role and are main exporters. Asian countries mainly act as importers and have pronounced "gatekeeper" role. Similarly, South American countries tend to play "gatekeeper" role and be mainly importers. USA and Canada have outstanding performance in "liaison" role. Summary interpretation could be that European countries have many intra-continental trade flows but then focus their inter-continental exports on only few key trading partners, where their 'counter-parts' are Asia and South America; i.e. countries from these continents focus on few key inter-continental import flows but then have many smaller-level intra-continental trade relations. USA and Canada serve as intermediaries between different continents; i.e. they tend to import a product from one continent and then export it to another. These patterns are consistent in all product groups, which indicates that some key factor affecting the development of graphic paper and pulp trade. In the LRQAP analysis, we further explore the relationship between paper and pulp trade networks and these factors.



2017

Figure 9. Newsprint trade networks by continents (dichotomization level: median value), 2017. In the figure, different colored nodes represent different continents, and each node is assigned one or more dominant broker roles. The reflective ties reveal trade flows within continents. The node size is scaled corresponding to its total trade and the ties between nodes are newsprint trade flow. *The numbers above ties are their trade value (unit: US$1000). Thick ties indicate trade flows greater than 100000.*

In summary, European countries are the main exporter and player in the graphic paper and pulp trade networks, and their roles remain almost stabile along these years. Noticeably, Asian countries are becoming more important in the trade networks, and their imported relations with European countries and North American countries increase from 1995 to 2017. Similar development of increasing the number of import partners exist for South American countries, especially Brazil.

Inferential Analysis

LRQAP analysis is conducted on newsprint trade of year 1995, 1998, 2005 and 2017. Table 4 shows results for attribute-effect regression models dichotomized on mean and median trade flow values, while Table 5 shows the same type of results for relational-effect regression models. The R^2 values in the mean-based attribute-effect model range from 6.3% to 8.9%, while the model with the same independent variables when applied on median dichotomized network shows slightly higher R^2 values, ranging from 7.6% to 9.9%. In both models, engagement in free trade agreement and contiguity are the most significantly positively correlated to the presence of trade relations between a pair of countries in the newsprint networks. Regarding the regression model dichotomized on mean value, absolute difference in GDP per capita and internet adoption rate also shows strong association with the presence of newsprint trade relations in 1995, 1998 and 2005, while weighted trade distance is not statistically significant in 1995 but becomes statistically associated with newsprint trade relations since 1998. In the model dichotomized on median level, absolute difference in internet adoption rate is positively associated with newsprint trade flow, while weighted trade distance is negatively associated with newsprint trade flow. In 2005 and 2017, countries which were ever in a colonial relationship are more likely to have trade relations.

The R^2 values in the mean-based relational-effect model range from 27.8% to 36.9%, while the model with the same independent variables when applied on median dichotomized network shows higher R^2 values, ranging from 39.5% to 46.9%. It can be observed in the relational-effect regression model dichotomized on mean value that contiguity, transitivity, and preferential attachment are positively associated with the presence of trade relations in the newsprint trade, while the engagement in free agreement become less important when introducing the network configuration variables into the model. Among endogenous factors, reciprocity does not show strong association with the presence of newsprint trade relations. Regarding the model dichotomized on median level, reciprocity shows strong positive relationship with the presence of trade relations in 2017, meanwhile, the significance of preferential attachment is decreasing. The significance of weighted trade distance and language similarity is increasing.

	1995		1998		2005		2017	
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Colony links	-0.532 0.725	0.120 ∘	0.594 1.027	0.180 *	0.910 1.050	∘ *	1.057 1.282	* **
Contiguity	1.305 1.291	** ***	1.401 1.300	*** ***	1.448 1.028	*** ***	1.199 1.165	*** ***
Language similarity	0.285 0.192	0.208 0.248	0.427 0.160	0.156 0.288	0.042 0.017	0.388 0.450	-0.316 -0.122	0.241 0.364
Engagement in free trade agreement	1.859 1.065	*** ***	1.593 0.870	*** ***	1.498 1.369	*** ***	1.839 1.453	*** ***
Weighted trade distance	-0.000 -0.000	0.241 *	-0.000 -0.000	* ***	-0.000 -0.000	** ***	-0.000 -0.000	* **
Absolute difference in forest area (%land area)	-0.006 0.000	0.257 0.389	0.007 0.008	0.231 ∘	0.006 0.005	0.234 0.222	0.008 0.003	0.192 0.343
Absolute difference in GDP per capita	-0.000 -0.000	** 0.296	-0.000 -0.000	*** ∘	-0.000 -0.000	∘ 0.334	0.000 0.000	0.243 *
Absolute difference in internet adoption rate	0.218 0.185	** ***	0.102 0.069	*** ***	0.021 0.023	* ***	-0.006 -0.012	0.304 ∘
Intercept	-4.720 -3.169		-4.742 -2.930		-4.183 -2.977		-4.119 -2.453	
R-Square	0.063 0.076		0.089 0.090		0.077 0.099		0.075 0.097	
Note: shown above are standardized coefficient. ∘ p value≤0.1; * p value≤0.05; ** p value≤0.01; *** p value≤0.001 Performed with 11772 observations and with 5000 permutations								

Table 4.Attribute-effect regression model coefficients and p value. Top values are for a model dichotomized on the mean and bottom ones are for a model dichotomized on the median trade flow value

	1995		1998		2005		2017	
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Colony links	-1.442 0.357	0.267 0.223	0.048 0.371	0.366 0.197	0.707 0.682	0.101 0.109	1.208 0.608	* 0.137
Contiguity	1.856 1.362	*** ***	1.701 1.490	*** ***	1.955 1.253	*** ***	1.457 1.513	*** ***
Language similarity	0.827 0.558	∘ ∘	0.723 0.651	0.101 ∘	0.610 0.807	0.116 *	0.281 0.830	0.265 *
Engagement in free trade agreement	0.763 0.379	∘ 0.117	0.917 0.277	* 0.175	0.487 0.287	0.102 0.165	0.680 0.058	* 0.407
Weighted trade distance	-0.000 -0.000	0.463 **	-0.000 -0.000	0.207 *	-0.000 -0.000	* *	-0.000 -0.000	∘ *
Reciprocity	0.554 0.349	0.179 0.184	1.016 0.300	* 0.185	0.414 0.568	0.171 ∘	0.480 0.858	0.130 ***
Transitivity	2.189 1.004	*** ***	2.006 1.029	*** ***	1.735 0.887	*** ***	1.477 0.674	*** ***
Preferential Attachment	0.325 0.085	*** **	0.232 0.050	** *	0.217 0.046	*** *	0.170 -0.005	*** 0.415
Intercept	-6.280 -4.155		-5.846 -4.008		-5.201 -4.087		-5.036 -3.894	
R-Square	0.369 0.395		0.345 0.416		0.310 0.456		0.278 0.469	

Note: shown above are standardized coefficient. ◦ p value≤0.1; * p value≤0.05; ** p value≤0.01; *** p value≤0.001 Performed with 11772 observations and with 5000 permutations

Table 5. Relational -effect regression model coefficients and p value. Top values are for a model dichotomized on the mean and bottom ones are for a model dichotomized on the median trade flow value

Discussion and conclusion

Our study maps the topology of graphic paper and pulp products trade networks on a global level and within it identifies the groups and roles of countries. We find that the trade networks are very sparse, and majority of trade value is concentrated on a few countries; which is consistent with previous findings that global trade is hierarchical and with core-periphery structure (Kali and Reyes, 2007; Lovrić *et al*, 2018). Regarding the longitudinal changes, increasing number of countries are involved in graphic paper and pulp trade, and they have closer trade relations with one another than before; which is in line with earlier studies on the evolution of the world trade networks (De Benedictis and Tajoli, 2011). Degree centrality results show that countries are more likely to trade products with others that have many connections, and that US and European countries behave as main players in international trade; which is similar to findings of De Benedictis *et al* (2014). Based on faction routine, countries that belong to the same continent are more likely to be grouped into the same faction and the faction partitions are stabile along the observed 23 years. This can be referred to trade regionalization mentioned by Koopmann and Vogel (2008), where they state that "despite globalization process, consumption and business activity continue to have a strong home market bias–with these home markets often crossing national borders and encompassing whole regions." Some trade unions can be identified from results (i.e., European Union, North American and Asian market). In general, the study results are consistent with previous publications. For example, Rougieux (2017) specified that people's demand for graphic paper is decreasing, which can also be seen from our study that trade value of graphic paper products shows a decreasing trend between 1995 and 2017. Ochuodho *et al* (2017) pointed out that the financial crisis has direct effect on graphic paper production and trade, and we can observe there is a dramatic drop between 2008 and 2009. Asian countries such as China, Philippines and Indonesia emerge as main trade partners in 2005 and 2017, which is aligned with previous findings that the role of Asian countries is strengthened (Hetemäki and Hurmekoski, 2016).

This study also shows many similar network structures to other studies that have from a network perspective assessed global trade, either in all or in a sub-set of commodities (Baulenas *et al*, 2021; Cantner and Rake, 2014). Kali and Reyes (2007) mapped the topology of world trade network by network statistics, such as degree centrality and network density. Compared with them, this study not only focuses on whole-system statistics but also grouping and roles. For example, countries tend to trade with countries belongs to the same group other than those outside the group. Structural changes are introduced when one country changes its group affiliation. Kali and Reyes (2007) combined substantive and relational variables into the gravity model for economic openness. While in this study, LRQAP analysis is conducted on the trade data, where trade networks are dependent variables, exogenous factors (attribute-based variables) and endogenous factors (network configuration variables) are independent variables. Our results reveal that contiguity and engagement in free trade agreement are positive correlated to the presence of trade relations in the newsprint networks. There has been previous empirical evidence for transitivity (Bai and Lee, 2013), preferential attachment (Maoz, 2012), and reciprocity (Tadajewski, 2009) facilitating tie formation in trade networks. In this study, transitivity and preferential attachment are positively associated with the presence of newsprint trade relations, while reciprocity does not show strong association with them.

Classical trade model, such as EFI-GTM model, is a gravity model and it only focuses on country-level analysis. Taken EFI-GTM as an example, it is aimed at describing the structure of the global forest sector and consists of a group of economies that are trading forest sector commodities (Kallio *et al*, 2004). The model includes individual country's characteristics (like economic growth, energy prices, forest growth) and provides price projections. Unlike classical trade model, network-based model does not try to predict trade value using endogenous factors (like trade distance, language similarity). It tests hypotheses related to the impact of endogenous and exogenous effect on the network (Lovrić *et al*, 2018). Our model provides insights of indirect trade relations and complex dependency. Trade networks are interconnected and complex and modelling the global trade and production only based on country level information or external factors may not be accurate. In our results, the regression model with country's attributes only explains small portion of variance of global newsprint trade networks, while the model with internal relational effect variables can explain up to half of the variance. The endogenous factors increase the explanatory power of the regression model.

One limitation of the study is that some SNA procedures, such as faction routine and brokerage analysis must be conducted on dichotomized data, and they provide very coarse-grained results. These procedures provide a good way to investigate structural properties of networks, and help identify the role and position of nodes, however, different dichotomization level may produce different results, therefore, we should use this method very carefully (Baggio, 2019). Another limitation is that the regression models in the LRQAP procedure can only explain up to half of variance of global trade networks. Besides that, the descriptive variables only consider classical ones covered in the previous models. Since LRQAP can only be conducted on dichotomized data, the results fail to take trade value between countries into consideration. To sum up, social network analysis provides a good way to study structural changes in global trade. The most important finding, up to now not observed in these commodities, is that the primary determinants of trade are not to be found within trading countries; but rather in the trade patterns themselves. It also must be stated that the presented LRQAP model is a relatively simple model with simple configuration. More insights could be gained by for example utilizing more complex models such as exponential random graph models (Lusher *et al*, 2013) or stochastic actor-oriented models (Snijders *et al.*, 2010), adding production as the second dependent variable (Steglich *et al*, 2010), using more exogenous and endogenous variables (Lovrić *et al*, 2018), interaction effects, and constructing a model with an ordered set of networks with increasing levels of dichotomization. To be self-critical, this study provides quite firm albeit general support to the notion that internal, endogenous 'determinants' of the trade should be included into econometric analysis. Our intention was to showcase what these ‘determinants’ could be; but we don’t go deep into providing appropriate conceptual understanding for any of them. For example, transitivity can be interpreted as a directed version of triadic closure, which in turn (Easley and Kleinberg, 2010) can be interpreted as local equilibrium of a social system, the propensity for which is an indication of developing more interconnected networks with very high clustering coefficients. Is transitivity higher in more stabile networks? Is there a price equilibrium among the transitive countries? Does higher transitivity lead to higher density across different commodity groups? These are the research questions which should be tackled next, in order to appropriately contextualize what transitivity in international trade means. The complexity of the issue is compounded by the fact that there are many ways to measure transitivity (e.g. Dekker *et al*, 2019) and that transitivity is not the only triadic relation in directed networks; where a thorough assessment of the local structures in international trade networks is warranted to contextualize the entire triadic census (Holland and Leinhardt, 1976).

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Appendix A. Terminology explanation

Term	Explanation
Adjacency matrices	a square matrix used to represent a graph
Beta centrality	beta centrality of each node is determined by the centrality of the node it is connected to. Beta value can be divided by positive and negative. Positive beta value(beta+) means the node's centrality is increased by being connected to nodes which have many connections themselves. Negative beta value(beta-) means the node's centrality is increased by being connected to nodes with few connections themselves
Brokerage analysis	Brokerage is an approach which can identify how the nodes are embedded in its neighborhood by observing how ego acts as an agent in relations among groups (Hanneman & Riddle, 2005). Possible brokerage relationships include: Coordinator: A →A → A (all nodes belong to same group) Gatekeeper: B→ A →A (source belongs to different group) Representative: A→ A → B (recipient belongs to different group) Consultant: B→ A → B (broker belongs to different group) Liaison: B→ A →C (all nodes belong to different groups)
Core-periphery analysis	A model of system that groups nodes into core class, which is nodes expected to have high density, while the periphery class has low density (Hanneman & Riddle, 2005).
Density (binary):	density in binary data means the proportion of present ties out of maximum number of all possible ties (Hanneman & Riddle, 2005)
Degree centrality	the number of the ties that a node has.
Dyad reciprocity	dyad reciprocity is defined as the ratio of reciprocal relationships in the network to the total number of dyads with any kind of relationship (reciprocal or otherwise) (Hanneman & Riddle, 2005)
Faction routine	Faction routine is a method which can identify substructure from networks by permuting adjacency matrix

Faction	A type of subgroup. Ideally, all ties for a faction are within the group and there are no ties outside the group
Indegree centrality	the number of ties that directed to the nodes
ISO code	the ISO codes are internationally recognized codes that designate every country and most of the dependent areas a three-letter combination
Multidimensional scaling	multidimensional scaling is a method visualizing the proximity of objects.
Node	a compulsory element forming networks. In this case, nodes are countries.
Outdegree centrality	the number of ties that the nodes directed to other nodes
Preferential attachment	The extent to which a node is more likely to be more popular due to its centrality (Mascia et al., 2020).
Quadratic assignment procedure	the quadratic assignment procedure (QAP) is a non-parametric statistical significance test, which is commonly used in social network analysis (Krackhardt, 1988)
Tie	a relation between a pair of nodes. In this case, ties are trade relations.
Transitivity	If A->B and B->C then A->C

Appendix B. Product groups and description

Product groups and description		HS92 code	Description
Newsprint		480100	Newsprint; in rolls or sheets
Printing &writing paper		480210	Paper and paperboard; hand-made
		480220	Paper and paperboard; uncoated, of a kind used as a base for photo-sensitive, heat-sensitive or electro-sensitive paper or paperboard, in rolls or sheets
		480230	Paper and paperboard; carbonising base paper, uncoated, of a kind used for writing, printing and other graphic purposes, in rolls or sheets
		480240	Paper and paperboard; wallpaper base, uncoated, in rolls or sheets
		480251	Paper and paperboard; uncoated, containing no, or not more than 10% by weight of fibres obtained by mechanical process, weighing less than 40g\/m2, in rolls or sheets
		480252	Paper and paperboard; uncoated, containing no, or not more than 10% by weight of fibres obtained by mechanical process, weighing 40g\/m2 or more but not more than 150g\/m2, in rolls or sheets
		480253	Paper and paperboard; uncoated, containing no, or not more than 10% by weight of fibres obtained by mechanical process, weighing more than 150g\/m2, in rolls or sheets
		480260	Paper and paperboard; uncoated, with more than 10% by weight of the total fibre content obtained by a mechanical process, in rolls or sheets
		480910	Paper; carbon and similar copying papers, whether or not printed, in rolls exceeding 36cm wide or in rectangular sheets with at least one side exceeding 36cm in unfolded state
		480920	Paper; self-copy paper, whether or not printed, in rolls exceeding 36cm wide or in rectangular sheets with at least one side exceeding 36cm in unfolded state
		480990	paper; copying and transfer paper (including coated or impregnated paper for duplicator stencils or offset plates), whether or not printed, in rolls exceeding 36cm wide or rectangular sheets with a side exceeding 36cm
		481011	Paper and paperboard; coated with inorganic substances only, having 10% or less of mechanically processed fibres, weight 150g\/m2 or less, for writing, printing or other graphic purposes, in rolls or sheets
		481012	Paper and paperboard; coated with inorganic substances only, having 10% or less of mechanically processed fibres, weight more than 150g\/m2, for writing, printing or other graphic purposes, in rolls or sheets
		481021	Paper and paperboard; light-weight coated paper, coated with kaolin or other inorganic substances only, having more than 10% of mechanically processed fibres, for writing, printing or other graphic purposes, in rolls or sheets
		481029	Paper and paperboard; coated with kaolin or other inorganic substances only, having more than 10% of mechanically processed fibres, (excluding light-weight paper), for writing, printing or other graphic purposes, in rolls or sheets
Mechanical wood pulp		470100	Wood pulp; mechanical wood pulp
Chemical wood pulp		470200	Wood pulp; chemical wood pulp, dissolving grades
		470311	Wood pulp; chemical wood pulp, soda or sulphate, (other than dissolving grades), unbleached, of coniferous wood
		470319	Wood pulp; chemical wood pulp, soda or sulphate, (other than dissolving grades), unbleached, of non-coniferous wood
		470321	Wood pulp; chemical wood pulp, soda or sulphate, (other than dissolving grades), semi-bleached or bleached, of coniferous wood
		470329	Wood pulp; chemical wood pulp, soda or sulphate, (other than dissolving grades), semi-bleached or bleached, of non-coniferous wood
		470411	Wood pulp; chemical wood pulp, sulphite, (other than dissolving grades), unbleached, of coniferous wood
		470419	Wood pulp; chemical wood pulp, sulphite, (other than dissolving grades), unbleached, of non-coniferous wood
		470421	Wood pulp; chemical wood pulp, sulphite, (other than dissolving grades), semi-bleached or bleached, of coniferous wood
		470429	Wood pulp; chemical wood pulp, sulphite, (other than dissolving grades), semi-bleached or bleached, of non-coniferous wood
Semichemical wood pulp		470500	Wood pulp; semi-chemical
pulp made from fiber other than wood		470610	Pulp; cotton linters pulp
		470691	Pulp; of fibrous cellulosic material (other than wood or cotton linters pulp), mechanical
		470692	Pulp; of fibrous cellulosic material (other than wood or cotton linters pulp), chemical
		470693	Pulp; of fibrous cellulosic material (other than wood or cotton linters pulp), semi-chemical
Recovered paper or paperboard		470710	Paper or paperboard; waste and scrap, of unbleached kraft paper or paperboard or of corrugated paper or paperboard
		470720	Paper or paperboard; waste and scrap, of paper or paperboard made mainly of bleached chemical pulp, not coloured in the mass
		470730	Paper or paperboard; waste and scrap, of paper or paperboard made mainly of mechanical pulp (eg newspapers, journals and similar printed matter)
		470790	Paper or paperboard; waste and scrap, of paper or paperboard n.e.s. in heading no. 4707 and of unsorted waste and scrap

Appendix C. Descriptive statistics of trade value

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range
1995	1454	21426	5102	37751	507	317325	3	11923387	11923384	4769
1996	1663	16804	4763	28844	343	250339	2	10019778	10019776	3123
1997	1684	13370	3696	23044	350	202397	2	8176262	8176260	2982
1998	1596	13551	3893	23210	311	196727	2	7729417	7729415	3168
1999	1714	11188	3151	19224	206	169632	2	6917132	6917130	2060
2000	1754	10758	2546	18969	218	175342	2	7256092	7256090	1864
2001	1868	9976	2975	16976	220	154271	2	6547100	6547099	1859
2002	1851	8263	2368	14159	217	129326	2	5472254	5472252	1517
2003	1851	8242	2634	13849	204	123009	2	5211000	5210595	1787
2004	1892	8452	3226	13678	239	115902	2	4946000	4946177	1870
2005	1955	8470	3423	13518	228	113806	2	4933958	4933956	1888
2006	1967	8458	3660	13257	241	108512	2	4703078	4703077	1795
2007	2034	7861	4290	11432	244	82130	1	3549278	3549276	2045
2008	1927	8191	4659	11724	294	79067	1	3315000	3315411	2463
2009	2017	5440	3408	7472	225	46539	1	1944483	1944481	1779
2010	1964	5438	3479	7397	216	44277	1	1801155	1801154	1504
2011	1842	6208	4035	8381	245	47544	1	1842561	1842560	2058
2012	1867	5158	3348	6968	213	39873	1	1578288	1578286	1691
2013	1761	4992	3207	6776	220	38177	1	1468618	1468617	1657
2014	1789	4525	2753	6296	161	38206	1	1504644	1504643	1319
2015	1827	3334	1963	4706	150	29893	1	1193281	1193280	941
2016	1748	3185	1885	4486	124	27721	1	1065707	1065706	907
2017	2615	3502	2103	4900	97	36482	1	1729000	1729456	721

Table C 1.Descriptive statistics of newsprint trade, 1995-2017

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range
1995	3574	21959.07	17018.76	26899.37	605	150638.3	3	6385017	6385014	4510
1996	3906	16349.73	12624.01	20075.46	431	118766.5	2	5361015	5361013	2967
1997	4048	14777.45	11259.38	18295.53	384	114168.9	2	5468389	5468387	3034
1998	4177	14296.27	10751.66	17840.89	347	116849.5	2	5688710	5688708	2564
1999	4353	13143.55	9802.51	16484.6	299	112436.6	2	5748425	5748423	2327
2000	4525	12709.38	9408.38	16010.38	301	113263.6	2	6171530	6171528	2234
2001	4650	11220.98	8168.59	14273.38	276	106171.1	2	5973629	5973627	2197
2002	4810	11654.65	8779.99	14529.31	273	101695.4	2	5545349	5545347	2277
2003	5008	12230.54	9442.01	15019.08	261	100659.7	2	5299183	5299181	2352
2004	5205	12796.48	9800.23	15792.73	257	110265.4	2	6115492	6115490	2298
2005	5311	12479.34	9521.81	15436.88	282	109943.8	2	6441683	6441681	2452
2006	5344	12373.18	9616.31	15130.06	291.5	102802.6	2	5765493	5765491	2415
2007	5507	12881.07	10259.56	15502.57	312	99234.93	1	5321677	5321676	2431
2008	5469	12998.88	10478.34	15519.42	328	95083.09	1	4961117	4961116	2624
2009	5370	10473.74	8481.65	12465.83	283	74464.7	1	3850409	3850408	2196
2010	5430	10603.65	8805.86	12401.43	300	67576.07	1	3182887	3182886	2288
2011	5388	10902.12	9114.75	12689.49	293	66924.08	1	2942965	2942964	2448
2012	5370	9644.15	8074.3	11214.01	275	58681.4	1	2526603	2526602	2147
2013	5337	9120.63	7636.81	10604.45	255	55294.73	1	2467529	2467528	2036
2014	5548	8461.6	7111.41	9811.79	219	51300.35	1	2319857	2319856	1858
2015	5377	7153.74	5983.21	8324.27	207	43783.11	1	1988761	1988760	1673
2016	5367	6629.09	5613.45	7644.73	199	37954.12	1	1567137	1567136	1541
2017	4731	6111.37	5280.7	6942.04	199	29143.76	1	727396	727395	1526

Table C 1. Descriptive statistics of printing and writing paper trade, 1995-2017

Year	N	Mean	95% Confidence	95% Confidence	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range

			Interval for Mean lower bound	Interval for Mean upper bound						
1995	351	4851	2960	6742	288	18012	3	190416	190414	2025
1996	378	3209	1851	4566	182	13423	2	161309	161306	1234
1997	388	2622	1526	3717	144	10973	2	125143	125140	878
1998	334	3028	1805	4251	168	11365	2	105412	105410	1058
1999	355	2342	1363	3321	96	9378	2	94612	94610	833
2000	369	2886	1822	3949	139	10389	2	102838	102836	1401
2001	363	2386	1508	3263	143	8502	2	82461	82459	1144
2002	383	2016	1314	2718	119	6988	2	78184	78182	961
2003	380	2008	1275	2741	97	7263	2	79950	79949	778
2004	394	1967	1188	2745	76	7862	2	100528	100526	502
2005	365	1961	1145	2777	78	7930	2	101937	101935	454
2006	367	2147	1305	2988	101	8197	2	84520	84519	570
2007	362	2253	1397	3109	104	8280	1	103462	103461	669
2008	340	2555	1534	3577	127	9574	1	106951	106950	751
2009	344	1739	1009	2470	82	6887	1	88312	88311	568
2010	354	2097	1212	2982	93	8464	1	96810	96809	499
2011	383	1749	931	2566	86	8140	1	106287	106286	436
2012	379	1494	788	2199	62	6982	1	97296	97295	303
2013	407	1118	643	1593	43	4876	1	59836	59834	298
2014	401	1142	592	1692	39	5602	1	68106	68105	274
2015	433	731	368	1093	31	3842	1	44602	44601	146
2016	391	667	290	1044	31	3792	1	49153	49152	167
2017	354	848	412	1283	42	4167	1	46435	46434	272

Table C 2.Descriptive statistics of mechanical wood pulp trade, 1995-2017

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range
1995	1266	46040	30710	61371	2076	278044	3	8147594	8147591	15968
1996	1308	28858	19622	38094	1532	170271	3	5098961	5098958	10295
1997	1342	25403	17122	33684	1287	154645	2	4752425	4752423	7768
1998	1385	22098	15228	28968	1082	130328	2	4035786	4035784	7224
1999	1396	21114	14394	27833	894	127982	2	4068210	4068208	7090
2000	1428	26893	18784	35001	901	156202	2	4894383	4894381	8136
2001	1540	19162	13552	24771	721	112226	2	3640315	3640313	6218
2002	1531	17822	12820	22823	694	99764	2	3142539	3142537	5797
2003	1511	19761	14505	25018	727	104168	2	3179652	3179650	5768
2004	1515	21635	15893	27377	668	113945	2	3507726	3507724	6734
2005	1523	21516	15851	27182	706	112714	2	3436629	3436627	6877
2006	1488	23917	17838	29997	835	119554	2	3467017	3467015	8299
2007	1554	26437	19749	33125	924	134416	1	3864995	3864994	8625
2008	1542	27457	20634	34280	958	136589	1	3783469	3783468	9241
2009	1491	20453	15336	25571	695	100744	1	2252754	2252753	6918
2010	1536	27590	20848	34332	1075	134709	1	3241047	3241046	8874
2011	1554	29114	21701	36527	1115	148980	1	3136511	3136510	9104
2012	1496	25520	19057	31983	911	127444	1	2337146	2337145	8909
2013	1478	26970	20191	33748	867	132853	1	2388646	2388645	9294
2014	1490	26081	19488	32674	905	129746	1	2449097	2449096	8142
2015	1471	24913	18480	31346	875	125773	1	2083773	2083772	8902
2016	1554	22039	16209	27869	670	117159	1	2242990	2242989	7080
2017	1508	24114	17409	30818	769	132729	1	2594479	2594478	7026

Table C 3.Descriptive statistics of chemical wood pulp trade, 1995-2017

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range

1995	264	6944	3758	10129	400	26288	3	248335	248332	2271
1996	277	4332	2035	6628	230	19419	3	232646	232643	1575
1997	276	3976	1671	6282	176	19454	2	256971	256969	1075
1998	260	3837	1826	5847	211	16461	2	196630	196628	1048
1999	250	4641	2162	7120	233	19900	2	202828	202825	1187
2000	282	5890	2717	9062	264	27062	2	278290	278288	1473
2001	267	4644	2400	6887	282	18618	2	196863	196861	1449
2002	294	4546	2245	6846	222	20041	2	261827	261825	1238
2003	322	5067	2189	7946	172	26254	2	398358	398356	1039
2004	314	5366	2023	8708	205	30100	2	469888	469887	1366
2005	310	5004	2325	7684	218	23973	2	336673	336672	1520
2006	336	5688	2652	8725	260	28296	2	449816	449814	1653
2007	313	6579	2620	10538	388	35601	2	553894	553893	1686
2008	345	7069	3386	10752	512	34783	1	548092	548091	3048
2009	299	5853	2303	9403	273	31194	1	483365	483363	2123
2010	334	7980	3178	12782	331	44613	1	716887	716886	2655
2011	311	6926	3017	10834	420	35032	1	531882	531880	2221
2012	320	6801	2426	11177	290	39779	1	651417	651416	2052
2013	324	6692	2474	10909	308	38585	1	634650	634649	2155
2014	289	7220	2582	11859	321	40062	1	638600	638599	3042
2015	374	4652	1529	7775	150	30710	1	558598	558597	1262
2016	360	4496	1371	7622	154	30155	1	544577	544576	1122
2017	348	5739	1464	10015	113	40549	1	723965	723964	1672

Table C 4.Descriptive statistics of semichemical wood pulp trade, 1995-2017

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range
1995	453	2212	1630	2794	213	6301	3	76397	76394	1499
1996	497	1630	1160	2100	145	5332	2	68815	68813	766
1997	552	1570	1141	1999	100	5128	2	56815	56813	740
1998	546	1465	1051	1879	108	4921	2	53104	53102	578
1999	566	1443	1053	1833	90	4727	2	57230	57228	522
2000	612	1506	1132	1880	106	4715	2	53876	53874	672
2001	645	1328	959	1698	94	4780	2	75930	75928	449
2002	680	1097	824	1370	88	3624	2	47404	47402	406
2003	689	1132	867	1398	81	3551	2	42301	42299	533
2004	718	1218	948	1489	108	3693	2	39771	39769	540
2005	842	1235	969	1501	81	3934	2	43163	43161	525
2006	824	1300	1023	1576	95	4040	2	42784	42782	599
2007	889	1309	1047	1571	88	3979	1	36863	36862	568
2008	975	1317	1062	1573	84	4066	1	38055	38054	564
2009	904	1153	900	1406	63	3874	1	50340	50339	396
2010	931	1281	1016	1547	77	4127	1	54717	54716	508
2011	869	1676	1297	2056	84	5700	1	70320	70319	590
2012	916	1281	991	1572	57	4484	1	56777	56776	465
2013	907	1081	852	1311	58	3516	1	34381	34380	414
2014	883	1109	870	1347	50	3607	1	34601	34600	382
2015	900	964	747	1182	48	3329	1	33738	33737	383
2016	1003	799	620	979	41	2899	1	40635	40634	234
2017	941	845	649	1041	36	3066	1	38479	38478	253

Table C 5.Descriptive statistics of pulp from fiber other than wood trade, 1995-2017

Year	N	Mean	95% Confidence Interval for Mean lower bound	95% Confidence Interval for Mean upper bound	Median	Std. Deviation	Minimum	Maximum	Range	Interquartile Range
1995	1160	9068	6032	12105	227	52714	3	1050075	1050072	1407
1996	1185	4344	2877	5812	130	25742	2	530139	530137	743
1997	1184	3688	2338	5039	123	23690	2	414167	414165	713
1998	1240	3233	2069	4398	111	20902	2	429144	429142	574

1999	1286	3367	2209	4525	110	21160	2	435940	435938	679
2000	1487	4487	3011	5963	111	29010	2	590007	590005	815
2001	1445	3263	2183	4344	102	20940	2	493686	493684	578
2002	1556	3408	2291	4525	93	22459	2	528897	528895	559
2003	1708	3807	2432	5183	81	28977	2	919938	919936	565
2004	1708	4420	2810	6030	99	33923	2	1053649	1053647	650
2005	1770	4666	2787	6545	94	40300	2	1337894	1337892	660
2006	1789	4802	2848	6757	88	42148	2	1436829	1436827	714
2007	1961	5875	3529	8220	105	52970	1	1896458	1896457	767
2008	1983	6623	3890	9356	115	62059	1	2285303	2285302	864
2009	1912	4821	2745	6896	96	46278	1	1662861	1662860	623
2010	2035	6435	3746	9123	122	61843	1	2346252	2346251	811
2011	2067	7553	4344	10762	124	74403	1	2912941	2912940	1014
2012	1973	6378	3338	9418	114	68855	1	2680222	2680221	853
2013	1989	5773	3017	8529	105	62668	1	2472125	2472124	804
2014	2034	5283	2829	7736	99	56425	1	2264023	2264022	763
2015	2013	4879	2541	7216	93	53472	1	2138182	2138181	684
2016	2010	4869	2625	7113	85	51306	1	2031940	2031939	700
2017	2018	5291	3038	7544	108	51603	1	2034874	2034873	821

Table C 6.Descriptive statistics of recovered paper and paperboard trade, 1995-201