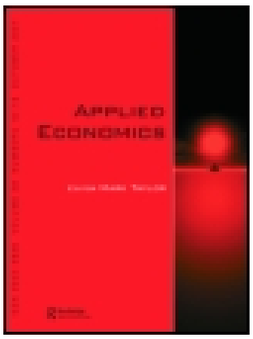

Routledge
Taylor & Francis Group

Applied Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/raec20

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To cite this article: Caihong Tang, Anitha Rosland, Jie Li & Rizwana Yasmeen (2023): The comparison of bilateral trade between China and ASEAN, China and EU: from the aspect of trade structure, trade complementarity and structural gravity model of trade, Applied Economics, DOI: 10.1080/00036846.2023.2174940

To link to this article: https://doi.org/10.1080/00036846.2023.2174940

APPLIED ECONOMICS
https://doi.org/10.1080/00036846.2023.2174940

The comparison of bilateral trade between China and ASEAN, China and EU: from the aspect of trade structure, trade complementarity and structural gravity model of trade

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ABSTRACT

This article mainly compares China's bilateral trade relation with the Association of Southeast Asian Nations (ASEAN) and with the European Union (EU), mainly from the perspective of China. We make the trade relation comparison in terms of trade volume and structure, trade complementarity index and impact factors on bilateral trade flow. We find the following results: (1) China mainly exports high-tech electronic and electrical and medium-tech products to ASEAN, and high-tech electronic and electrical and low-tech manufactures to EU yet imports high-tech electronic and electrical products from ASEAN and medium-tech products from EU. (2) China has strong competitiveness in low-tech manufactures and high-tech electronic and electrical area yet comparatively low competitiveness in medium-tech area; (3) China has high trade complementarity with EU in low-tech area and high trade complementarity with ASEAN in high-tech electronic and electrical area; (4) Based on structural gravity model of trade, the GDP per capita, monetary freedom, trade freedom and human development index have significant impacts on China-ASEAN and China-EU bilateral trade; WTO membership has impact on China's trade with ASEAN yet not with EU; distance has impact on China's trade with EU yet not with ASEAN.

KEYWORDS

China-ASEAN; China-EU; trade structure; trade complementarity; structural gravity model of trade

JEL CLASSIFICATION

F140; F400

I. Introduction

It has been more than 10 years since the China-ASEAN Free Trade Area (CAFTA) was fully established. As previous researchers predicted, both China and ASEAN have achieved great success from this trade agreement and now ASEAN is China's biggest trade partner. Although China's trade relation with ASEAN has been greatly changed, China's trade relation with EU has been continuously growing. Both ASEAN and EU are China's largest trade partners and have intense trade relation with China. However, ASEAN is an emerging economy and EU is a developed economy. There must be some differences between China-ASEAN and China-EU bilateral trade. Based on our literature review, we find that abundant researches have studied the trade relation of China-ASEAN and China-EU in terms of trade flow and trade intensity. Yet no research has compared the bilateral trade between China-ASEAN and China-EU. To study the trade differences between China-ASEAN and China-EU is significant for China to know better about the trade relation with its two biggest trade partners and provides relevant reference value for China's decision makers. Moreover, it provides some reference experience for other developing countries when making related trade policies. Our research examines the bilateral trade between China-ASEAN and China-EU, mainly from the perspective of China. First, we make a comparison in terms of commodity trade value, trade structure and trade complementarity based on LALL classification trade data from UNCTAD database. Secondly, we collect panel data of China's trade with ASEAN and EU countries and employ structural gravity model of trade, which is frequently used for bilateral trade analysis, to compare the impact factors on bilateral trade between China-ASEAN and China-EU.

II. Literature review

China-ASEAN trade relation

After the full establishment of CAFTA, some researchers also examine the trade creation between China and ASEAN under this agreement.

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With an extended gravity model, Sheng, Tang, and Xu (2012) find that after the signature of CAFTA, the component trade between China and ASEAN has increased more largely than previous studies predicted, and the trade intensity between them is becoming stronger. Shohibul (2013) calculates the revealed comparative advantage index based on SITC revision 3 for China and ASEAN countries and finds that China trade pattern has been formed, yet that of ASEAN is dynamic, and China has comparative advantages over manufactured products. Yang and Martinez-Zarzoso (2014) employ justified gravity model of trade to study trade creation effect of the China-ASEAN Free Trade Agreement with a sample of 31 countries and find a positive impact on their trade flows. Hooy, Siong-Hook, and Tze-Haw (2015) find that the high-tech exports of ASEAN to China are more easily affected by the devaluation of the RMB, and the exchange rate of RMB positively affects the total exports of ASEAN to China. Chiang (2019) finds that China has trade surplus with ASEAN in commodity trade since 2012, China's comparative advantages in labour force are declining, and the investment from China to ASEAN has been rising and becoming more diversified. In some industries, such as construction, telecommunication and IT area, China has comparative advantages in ASEAN countries and ASEAN has large financial and tourism markets in China. Devadason and Chandran (2019) try to investigate the trade potential relation between China and ASEAN countries and find that China's trade with Vietnam is different from other ASEAN members in agriculture and manufacture area. They argue that Vietnam's trade efficiency with China is similar to the efficiency of other ASEAN members' trade with China, and both large and small side can benefit from trade between China and ASEAN. Based on gravity model, Jie and Zhihong (2020) find that GDP promotes trade flow between China and ASEAN, while China and ASEAN free trade area (CAFTA) has insignificant positive effect on trade creation. They argue that distance has a negative relation with trade volume and China and ASEAN should enhance economic and trade cooperation in the coming future. Alleyne, Zhang, and Mu (2020) indicate that CAFTA has improved export efficiency and generated more sustainable trade from ASEAN to China, both at the national and industry level, by using a structured gravity model. Tran et al. (2020) indicate that the trade relation between China and ASEAN has been developing very fast and specially in the high-tech and medium-tech areas and there is large trade potential between China and some ASEAN members, such as Malaysia, Brunei and Laos. They argue that China and ASEAN should take more proactive measures to enhance their trade relation based on mutual political trust. Bi (2021) discusses the economic cooperation between China and ASEAN and argues that under CAFTA, China and ASEAN gradually reduce trade blocks and increase cooperation in trade, investment and manufacturing areas. However, there are some challenges facing by China and ASEAN to have a much deeper cooperation. For example, China and ASEAN have similar comparative advantages in some area, and thus there are trade competition and investment competition between them. They advise that China and ASEAN should optimize the bilateral trade structure and economic cooperation, adjust their labour division according to their competitive advantages to improve complementarity.

China-EU trade relation

Trade relation between China and EU has been examined by abundant researchers. Levinger and Hansakul (2016) argue that China and EU will continue to be their mutual key trade partner. With the development of China's economy, its demand for goods and services has changed. Yet EU will keep on providing complementary products and remain the source of high-tech products and services. The research of Herrero and Xu (2017) demonstrates that EU countries, especially landlocked EU countries, can benefit from China's BRI, which reduces transportation costs. They argue that if China has an FTA with BRI countries, EU members could not benefit unless these states are included in the BRI. Using multiple regression analysis, Li, Bolton, and Westphal (2018) find that the Belt and Road Initiative has increased the trade between China and its partners in Europe and boosted the exports of China's manufactured goods to the EU and the imports of food and live animals to China. Jiang et al. (2019) try to examine

the large trade balance between China and EU and find that there is large difference about trade statistics published by China and EU. According to the adjustment of China-EU trade balance in terms of price, mark-ups and re-exports and shipping cost, the trade balance shrinks largely, and in valued-added terms, the trade balance shrinks further. Garcia-Herrero (2020) investigates China-EU economic relation from the aspect of trade and investment and concludes that with the Belt and Road Initiative (BRI) of China, China will still be EU's largest trade partner and investment partner in the future and the EU should find more opportunities to co-exist with China and realize mutual trade and investment development. This researcher argues that although there are many problems in economic cooperation between China and EU, the trade relation between them has the least problems; the BRI will help to improve the connection between China and EU to create more trade and benefits for both China and EU yet also brings challenges to EU countries. Goulard (2020) argues that the US–China trade has a disruptive influence on world trade. The impact of this trade war may benefit some emerging economies in ASEAN by seizing the opportunities to export more to the US market, but it is hard to analyse the impact of this trade war on EU and on EU's trade diversion as EU is a complex economy. He implies that US–China trade war benefits little to EU industries in terms of tourism, real estate and education. Jindřichovská and Uğurlu (2021) employ monthly data from UNCTAD to analyse the trade between China and EU during the COVID-19 pandemic. They find that this pandemic negatively affect China's trade volume with EU and the change of demand from EU causes export structure changes of China, especially high demand in healthcare and medical area. This implies that China's export structure can be flexible with demand changes. Chen et al. (2021) show that the trade between the EU and China weakens the trade relations among EU countries and the impact as an export destination on the EU is larger than that of China as an import source.

Based on our literature review, we find that abundant researches have studied the trade relation of China-ASEAN and China-EU in terms of trade flow and trade intensity. Yet no research has compared the bilateral trade of China-ASEAN with China-EU. To study the bilateral trade differences between China-ASEAN and China-EU is significant for China to know better about the trade relation with its two biggest trade partners and provides relevant reference value for policy making of China and other developing countries.

III. China's commodity trade volume and structure with ASEAN and with EU

In this part, we employ data based on the LALL classification from UNCTAD database to analyse the bilateral trade of China-ASEAN and China-EU in terms of trade volume and structure. Lall (2000) classifies the exports in terms of technical levels into primary products, resource-based manufactures, low technology manufactures, medium technology manufactures, high technology manufactures and other unclassified products. This kind of classification can more clearly show the technology level of the export products and are used by plenty of researchers to study trade relations.

Table 1 shows the bilateral commodity trade volume. Since 1996, China's total commodity trade volume with ASEAN and with EU has been increasing fast, and over a long period, its commodity trade volume with EU has grown faster than that with ASEAN. Before 2018, China's total commodity trade volume with EU is larger than that with ASEAN yet in 2019, ASEAN became China's largest commodity trade partner. Moreover, China imports largely from EU and ASEAN, but after 2014 China's imports from ASEAN are larger than that of EU. China's exports volume to EU is far larger than to ASEAN before 2014, but the gap is decreasing fast. Before 2012, China had a trade deficit with ASEAN, and after that, China had a gradually increasing trade surplus, while China's commodity trade with EU has been in surplus since 1997, and the surplus has been growing rapidly. For a long time in the past, China's trade with EU accounts for larger part of China's total trade than that with ASEAN, but after 2010, China's trade with ASEAN increases extremely fast mainly due to the full establishment of CAFTA.

Table 1. China-ASEAN, China-EU bilateral commodity trade (unit: $US billion).

	China's total trade with				China's export to				China's import from			
Year	ASEAN	prop	EU	prop.	ASEAN	prop.	EU	prop.	ASEAN	prop.	EU	prop.
1996	21.16	0.07	34.20	0.12	10.31	0.07	16.88	0.11	10.85	0.08	17.32	0.12
1998	23.80	0.07	41.82	0.13	11.16	0.06	23.81	0.13	12.63	0.09	18.01	0.13
2000	39.52	0.08	62.55	0.13	17.34	0.07	34.82	0.14	22.18	0.10	27.73	0.12
2002	54.78	0.09	81.48	0.13	23.58	0.07	45.02	0.14	31.20	0.11	36.46	0.12
2004	105.87	0.09	159.78	0.14	42.90	0.07	94.03	0.16	62.97	0.11	65.76	0.12
2006	160.84	0.09	250.88	0.14	71.31	0.07	166.69	0.17	89.53	0.11	84.19	0.11
2008	231.32	0.09	382.20	0.15	114.32	0.08	259.03	0.18	117.00	0.10	123.17	0.11
2010	292.84	0.10	431.12	0.14	138.16	0.09	274.01	0.17	154.68	0.11	157.11	0.11
2012	400.14	0.10	484.62	0.13	204.27	0.10	289.27	0.14	195.87	0.11	195.34	0.11
2014	480.29	0.11	534.43	0.12	272.05	0.12	313.98	0.13	208.24	0.11	220.45	0.11
2016	452.31	0.12	473.12	0.13	256.00	0.12	283.66	0.14	196.31	0.12	189.46	0.12
2018	589.75	0.13	603.61	0.13	320.66	0.13	353.80	0.14	269.09	0.13	249.81	0.12
2020	684.59	0.15	649.92	0.14	383.72	0.15	391.36	0.15	300.87	0.15	258.57	0.13

prop. indicates the proportion Source from UNCTAD.

The commodity trade structure of China-ASEAN and China-EU is illustrated in Figures 1–4. China's most exports to ASEAN are low-tech, medium tech and high-tech manufactures, accounting 26.6%, 28.1% and 26.4%, respectively, in 2019. Among them, high-tech E&E and medium-tech engineering products have the highest proportion (24.2%, 17.7%, respectively, in 2019). China's most exports to EU are high-tech, low-tech and medium-tech manufactures, accounting 34.1%, 30.9% and 25.2%, respectively, in 2019. Among them, high-tech E&E and medium-tech engineering products have the largest proportion (30.7%, 18.8%, respectively, in 2019). China's main imports from ASEAN are high-tech, resource-based and medium-tech manufactures, accounting 43.8%, 18.8% and 13.6%, respectively, in 2019. Among them, high-tech E&E products have the highest proportion (41% in 2019). China's main imports from EU are

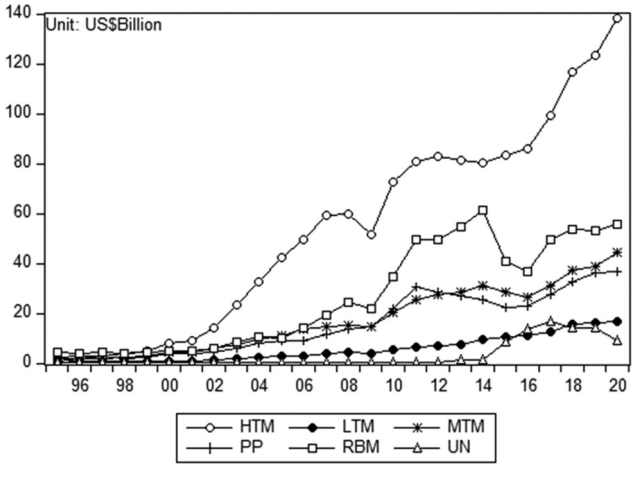

Figure 1. China's imports from ASEAN.

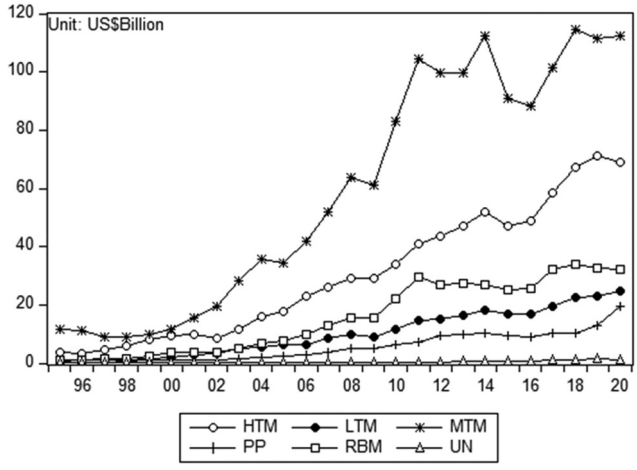

Figure 2. China's imports from EU.

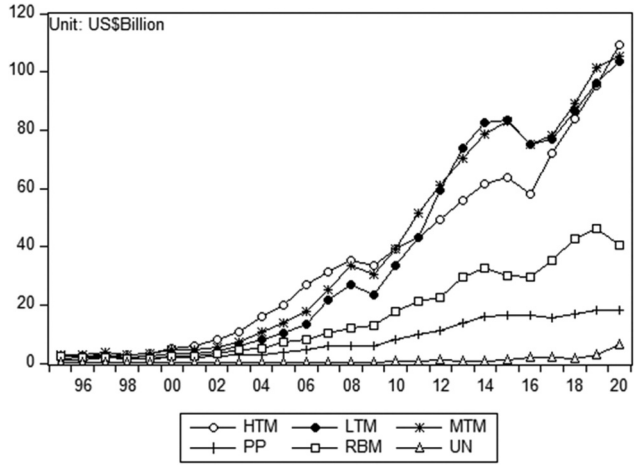

Figure 3. China's exports to ASEAN.

medium-tech and high-tech products, accounting 44.1% and 28.2% in 2019. Among them, medium-tech engineering, automotive and high-tech other products have the largest proportion (22.4%, 14.1%

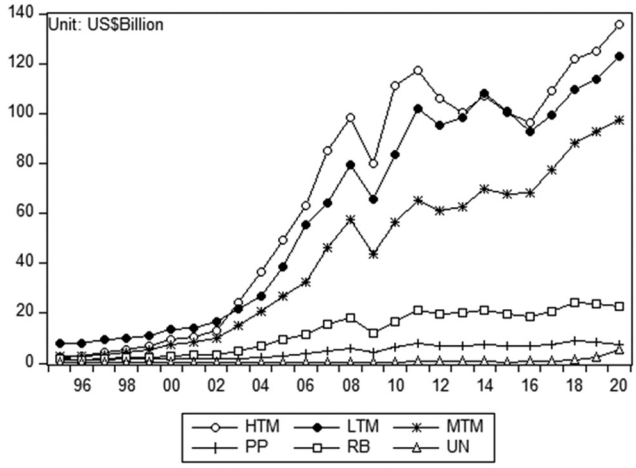

Figure 4. China's exports to EU.

and 18%, respectively, in 2019). It's surprising that China's imports from ASEAN are mainly high-tech E&E products (above 40%) and its main imports from the EU are medium-tech products (above 40%). The reasons might be (1) EU limits high-tech exports to China, and some ASEAN countries play the role of intermediaries to export to China; (2) China imports high-tech components and parts from ASEAN, assemblies them into final products and then exports them to ASEAN, EU and other countries. The large trade volume (exports and imports) between China and ASEAN in E&E products indicates high intra-industry trade between them which can benefit both China and ASEAN.

PP: Primary Products; RBM: resources-based manufactures; LTM: low-tech manufactures;

MTM: middle-tech manufactures; HTM: high-tech manufactures; UN: unclassified;

Source: Figures 1–4 are made based on data from UNCTAD.

IV. China's RCA index and trade complementarity with ASEAN and with EU

In this research, we also employ the data from UNCTAD and calculate the revealed comparative advantage (RCA) index of China's export products and the trade complementarity index of China's exports to ASEAN and EU. The calculation equation of the RCA index is as follows:

$$RCA_{ik} = \frac{(x_{ik}/x_i)}{(x_{wk}/x_w)} \quad (1)$$

Here i and k indicate country i and product k. x_{ik} and x_{wk} refer to the export value of country i's product k and world total export value of product k, x_i and x_w the total export value of country i and the world total export value. When the index is above 1, country i's product k has a revealed comparative advantage in the world market; otherwise, it has a disadvantage.

Moreover, the trade complementarity index (TCI), which can indicate the trade intensity between trade partners, is calculated between China and ASEAN, China and EU to compare. The calculation equation of TCI is as follows:

$$TCI_{ijk} = RCA_{xik} * RCA_{mjk} \quad (2)$$

$$RCA_{xik} = \frac{x_{ik}/x_i}{x_{wk}/x_w} \quad (3)$$

$$RCA_{mjk} = \frac{m_{jk}/m_j}{x_{wk}/x_w} \quad (4)$$

TCIijk indicates the trade complementarity index between country i's export and country j's import at product k, RCA_{xik} export country i's revealed comparative advantage index on product k, RCA_{mjk} import country j's revealed comparative disadvantage index on product k. x_{ik} and x_i represent country i's export value of product k and total export value of country i, x_{wk} and x_w the world export value of

product k and the total world export value, m_{jk} and m_j country j's import value of product k and total import value of country j. If the TCI value is greater than 1, it indicates trade complementarity between the two countries in terms of product k is high. The greater the value, the greater the strength of trade complementarity, and the higher the degree of overlap between the commodities exported by country i and imported by country j.

RCA of China's export products in the world market

The RCA indexes of China's export products are calculated based on Equation (1). The results (Table 2) show that although the RCA index of China's low-tech products (textile, garments and footwear) has been declining since 1996, it has still remained above 2.3 until 2020, indicating that the competitiveness of China's textile, garment and footwear products (labour intensive) is decreasing greatly yet still strong in international market. The RCA index of China's low-tech other products ranges from 1.6 to 2.0, keeping stably strong for the past 20 years. Although in the 1990s, China's medium-tech engineering products are comparatively weak in the world market, the competitiveness has been increasing steadily. After 2005, the RCA index is between 1.0 and 1.25, indicating strong competitiveness. China's high-tech electronic and electrical (E&E) products had weak competitiveness before 2000, yet after that the competitiveness has been increasing fast, with the RCA index growing from 1.0 to 2.4, indicating a strong increasing competitiveness. The RCA indexes of China's primary products and resource-based manufactured products show no comparative advantage and even their competitiveness has been decreasing. Even though the competitiveness of China's medium-tech automotive has been growing for the past years, these products still have very weak competitiveness. Additionally, China's medium-tech process products and other high-tech products have no comparative advantage in the world market.

To sum up, China still has strong comparative advantages in low-tech manufacture area, increasingly strong competitiveness in high-tech E&E area and comparatively good competitiveness in medium-tech engineering area and weak competitiveness in primary, resource-based and medium-tech automotive and process manufactures. Before 2000, China's competitiveness is concentrated in low-tech manufacture area (labour intensive). However, after that, with China's economic development and China's deeper opening to the world, China's industrial structure has been improving and upgrading, which can also be reflected by China's exports structure changes and China's increasing competitiveness in medium-tech area and high-tech area. China's industrial upgrading and improving competitiveness also lead to China's trade creation and trade diversion, which can be reflected by the changing RCA indexes of China's exports. It's interesting to see that China shows high competitiveness in low-tech and high-tech E&E area yet low competitiveness in medium-tech area, which might be due to insufficient capital and technology investment in this area. Moreover, in high-tech E&E area, in many cases, China only

Table 2. RCA indexes of China's export products.

	PP	RBM*	RBM other	LTM**	LTM other	MTM automotive	MTM process	MTM engineering	HTM***	HTM other	UN
1996	0.686	0.678	0.732	4.083	1.779	0.106	0.777	0.732	0.872	0.508	0.143
1998	0.684	0.533	0.733	3.836	1.849	0.109	0.774	0.760	1.002	0.470	0.135
2000	0.524	0.616	0.624	3.811	1.919	0.176	0.848	0.869	1.132	0.476	0.122
2002	0.451	0.565	0.606	3.373	1.781	0.162	0.667	0.940	1.579	0.334	0.137
2004	0.327	0.530	0.567	3.123	1.608	0.192	0.785	0.985	1.974	0.463	0.098
2006	0.247	0.597	0.477	3.226	1.691	0.249	0.764	1.053	2.151	0.457	0.109
2008	0.182	0.534	0.510	3.239	1.812	0.341	0.802	1.164	2.369	0.549	0.088
2010	0.185	0.512	0.450	3.170	1.703	0.322	0.711	1.225	2.296	0.591	0.077
2012	0.158	0.581	0.411	3.179	2.008	0.371	0.770	1.256	2.396	0.623	0.071
2014	0.166	0.553	0.447	2.924	2.021	0.355	0.770	1.197	2.242	0.521	0.077
2016	0.238	0.527	0.515	2.649	1.796	0.321	0.735	1.171	2.043	0.470	0.099
2018	0.196	0.546	0.553	2.562	1.840	0.372	0.814	1.196	2.104	0.460	0.090
2020	0.203	0.459	0.518	2.333	1.866	0.384	0.716	1.226	1.906	0.427	0.254

RBM*: RBM agro-based; LTM**: LTM textile, garment and footwear; HTM***: HTM electronic and electrical.
Source: RCA indexes are calculated based on data from UNCTAD.

plays a role of assembly. Although the export volume of high-tech E&E products is large, the added value generated is very low. The changes of China's RCA indexes also show that China has an increasing competitiveness in more areas but has an imbalanced development in its industrial structure which should be continuously improving and optimizing.

Trade complementarity of China-ASEAN and China-EU

Here we take China as the exporter, ASEAN and EU as the importer to calculate China's trade complementarity indexes (TCI) with ASEAN and EU, respectively. The TCI indexes are calculated according to Equation (2) and reported in Tables 3 and 4. First, China has no trade complementarity with both ASEAN and EU in primary and resource-based manufactures. This is because China does not have comparative advantages and competitiveness in those two areas, and China's exports of those products to ASEAN and EU account only very tiny proportion. Second, China has high trade complementarity both with ASEAN and EU in low-tech manufactures. However, China's TCI indexes of low-tech products are much higher in EU market than in ASEAN market. China's TCI of low-tech textile products with EU in most years is more than 3, while this index with ASEAN ranges 1.5–1.8. China and ASEAN are developing countries with low labour cost, and both have strong comparative advantages in low-tech manufacture area; EU is a highly developed economy with high labour cost and has no comparative advantages in the low-tech area. Thus, China's export of low-tech products is far more complementary with EU than with ASEAN. Third, China's medium-tech automotive and process manufacturers have no trade complementarity with ASEAN or with EU as China's comparative advantages in those two areas are weak, especially in automotive area. However, China has

Table 3. China's TCI with ASEAN (China as exporter).

	PP	RBM*	RBM other	LTM**	LTM other	MTM auto	MTM process	MTM engineering	HTM***	HTM other	UN
1996	0.510	0.384	0.683	1.716	1.603	0.052	0.778	0.945	1.678	0.485	0.120
1998	0.612	0.308	0.677	1.796	1.538	0.020	0.808	0.865	2.070	0.429	0.104
2000	0.433	0.379	0.664	1.878	1.463	0.061	0.944	0.933	2.222	0.321	0.066
2002	0.402	0.350	0.653	1.628	1.297	0.053	0.749	0.952	3.251	0.229	0.108
2004	0.287	0.316	0.639	1.497	1.203	0.065	0.888	0.996	4.028	0.317	0.067
2006	0.223	0.365	0.564	1.588	1.269	0.075	0.819	1.037	3.443	0.322	0.238
2008	0.162	0.346	0.647	1.655	1.556	0.131	0.874	1.249	3.841	0.369	0.114
2010	0.159	0.367	0.564	1.671	1.535	0.148	0.796	1.363	3.515	0.372	0.079
2012	0.134	0.439	0.543	1.872	1.922	0.191	0.905	1.465	3.464	0.445	0.048
2014	0.154	0.401	0.620	1.817	1.927	0.146	0.904	1.293	3.172	0.343	0.058
2016	0.228	0.424	0.619	1.875	1.779	0.146	0.919	1.280	2.934	0.308	0.067
2018	0.182	0.418	0.691	1.812	1.769	0.156	1.013	1.232	2.956	0.321	0.079
2020	0.197	0.354	0.593	1.760	1.825	0.170	0.910	1.313	2.716	0.279	0.145

*RBM: agro-based; ** LTM: textile, garment and footwear; ***HTM: electronic and electrical.
Source: TCI indexes are calculated based on data from UNCTAD.

Table 4. China's TCI with EU (China as exporter).

	PP	RBM*	RBM other	LTM**	LTM other	MTM auto	MTM process	MTM engineering	HTM***	HTM other	UN
1996	0.725	0.756	0.743	4.149	1.903	0.119	0.849	0.661	0.670	0.514	0.163
1998	0.707	0.599	0.742	3.787	1.952	0.121	0.849	0.719	0.828	0.477	0.131
2000	0.528	0.700	0.619	3.622	2.039	0.195	0.927	0.848	0.880	0.528	0.153
2002	0.467	0.647	0.597	3.230	1.861	0.177	0.721	0.919	1.237	0.399	0.131
2004	0.319	0.604	0.531	3.056	1.714	0.224	0.830	0.944	1.502	0.540	0.124
2006	0.243	0.689	0.455	3.252	1.862	0.288	0.807	1.019	1.654	0.526	0.117
2008	0.172	0.635	0.453	3.492	2.051	0.404	0.839	1.133	1.864	0.639	0.095
2010	0.187	0.612	0.401	3.544	1.929	0.363	0.734	1.165	1.789	0.715	0.073
2012	0.167	0.708	0.392	3.627	2.307	0.391	0.821	1.204	1.769	0.773	0.047
2014	0.168	0.684	0.406	3.442	2.351	0.395	0.832	1.183	1.600	0.632	0.057
2016	0.246	0.628	0.465	3.088	2.083	0.384	0.805	1.164	1.399	0.557	0.068
2018	0.192	0.645	0.492	3.044	2.197	0.467	0.873	1.212	1.438	0.540	0.073
2020	0.190	0.542	0.457	2.851	2.185	0.490	0.749	1.249	1.344	0.521	0.218

*RBM: agro-based; ** LTM: textile, garment and footwear; ***HTM: electronic and electrical.
Source: TCI indexes are calculated based on data from UNCTAD.

comparatively increasing and good trade complementarity with ASEAN and EU in medium-tech engineering area. The TCI indexes with ASEAN and EU in this area are close in each year, ranging from 1.0 ~ 1.3 after 2004. Fourth, China's trade complementarity is high with both ASEAN and EU in high-tech E&E area. However, its TCI index in this area is much higher in ASEAN market than in EU market. In this area, China's trade complementarity with ASEAN market is continuously high, ranging from 2.0 ~ 4.0 and in most years the number is larger than 3.0. Comparatively, China's trade complementarity indexes with EU range from 1.0~1.8. China's competitiveness in high-tech is low if it is compared with EU, yet it is high if it is compared with developing countries. China has its own technological advantages in the electronic and electrical area and also plays a role in the assembly of high-tech products. Therefore, in this high-tech area, China has high trade complementarity with ASEAN and EU, yet China is far more complementary with ASEAN than EU.

V. Data and methodology

Besides comparing China's bilateral trade volume, structure and complementarity with ASEAN and the EU, we collect the panel data from 2000 to 2018 for 9 ASEAN countries and 25 EU countries. We apply the gravity model to analyse the factors which affect China's bilateral trade with them. The gravity model of trade is commonly used in the researches of bilateral trade. It is first proposed by Isard (1954), and it shows that bilateral trade flows are positively affected by the two countries' GDP size yet negatively by their distance. The basic model of trade gravity model is defined as follows:

$$TV_{ij} = A \cdot \frac{G_i G_j}{D_{ij}} \tag{5}$$

Here TV_{ij} is the total trade volume between country i and country j. A is a constant. G_i and G_j stand for the GDP of country i and country j. D_{ij} is the physical distance between country i and country j. After natural logarithm of both sides is taken in the equation, it becomes:

$$lnTV_{ij} = \beta_0 + \beta_1 lnG_i + \beta_2 lnG_j + \beta_3 lnD_{ij} + e_{ij} \tag{6}$$

In addition to the GDP and distance, we include more variables in our gravity model of trade, such as population, monetary freedom index, trade freedom index, WTO and human development index. Here, we use the variable GDP per capita to replace variable GDP to avoid the collinearity between GDP and population in the model. Then, we define our trade gravity model in this research as follows:

$$\begin{aligned} \ln TV_{ijt} = {} & \beta_0 + \beta_1 \ln GDPP_{it} + \beta_2 \ln GDPP_{jt} \\ & + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DISC_{ij} \\ & + \beta_6 \ln MONF_{jt} + \beta_7 \ln TRFR_{jt} \\ & + \beta_8 WTO_{jt} + \beta_9 HDI_{jt} + \in_{ijt} \end{aligned} \tag{7}$$

Here i, j and t represent China, China's trading partner country and year, respectively. The dependent variable TV_{ijt} refers to China's total trade volume (export + import) with its trading partner country j in year t at the current US$. The independent variables $GDPP_{it}$ and $GDPP_{jt}$ refer to the gross domestic product per capita of China and China's trading partner j, respectively, in year t at the current US$. POP_{it} and POP_{jt} stand for a population of China and China's trading partner j, $DISC_{ij}$ the physical distance from China's capital Beijing to the capital of China's trading partner j, $MONF_{jt}$ monetary freedom index of country j, $TRFR_{jt}$ trade freedom index of country j. WTO_{jt} indicates whether country j is a WTO member in year t. HDI_{jt} refers to the human development index of country j in year t. The detailed information of our variables can also be found in Table 5. The GDP per capita and population data are collected from the World Bank, and China's bilateral commodity trade value is from UNCTAD. The data of capital distance and WTO membership come from the CEPII database. The monetary freedom index and trade freedom index data are from the World Heritage Fund. The human development index data come from United Nations Development Programmes. In our model, we hypothesize that the GDP per capita, population, monetary freedom, trade freedom, membership of WTO and human development index have a positive relation with bilateral trade flow, and

Table 5. Details of variables.

Variable	Specific meaning	Expectation	Time span	Source
Dependent variable				
TVijt	Bilateral trade volume between country i China to country j		2000–2018	UNCTAD
independent variable				
GDPPit	GDP per capita of country i China in year t	positive	2000–2018	WORLDBANK
GDPPjt	GDP per capita of country j in year t	positive	2000–2018	WORLDBANK
POPit	Population of country i China in year t	positive	2000–2018	CEPII
POPjt	Population of country j in year t	positive	2000–2018	CEPII
DISCij	Physical capital distance from country i China to country j	negative	2000–2018	CEPII
MONFjt	Monetary freedom index of country j in year t	positive	2000–2018	World Heritage Fund
TRFRjt	Trade freedom index of country j in year t	positive	2000–2018	World Heritage Fund
WTOjt	Whether country j is a member of WTO; dummy variable	positive	2000–2018	CEPII
HDIjt	Human development index of country j in year t	positive	2000–2018	United Nations Development Programs

Here i, j, t indicate China, China's trading partner, year t respectively.
We use the score of 100 for the monetary freedom index, trade freedom index and human development index.

the distance has negative relation with bilateral trade flow. We employ panel data from 2000 to 2018 of 34 China's trading countries (9 ASEAN countries+25 EU countries). At first, we use the whole sample data to have a panel data regression to check the results. Then, we split the data into sub-samples, namely: (i)China-ASEAN and (ii) China-EU for a comprehensive comparison.

VI. Empirical results

The Stata 17.0 software is used to analyse the data in this study. Here, we employ our trade gravity model to analyse the whole sample first and then sub-samples. The panel data regression results are reported in Tables 6, 7 and Table 8. We report our panel data regression results of four estimation methods: OLS regression, GLS regression, fixed-effect regression and random-effect regression. For our whole sample, the Hausman test result indicates that the fixed effect model is more preferred than the random effect model. Thus, we mainly explain the results of the fixed-effect model. Table 6 shows the regression results of the whole sample. The results indicate that the GDP per capita of China's trade partner has a significant positive impact on China's bilateral trade flow with a coefficient of 0.67 ($p < 0.01$). The population of China's trade partner has a significant negative impact on its bilateral trade, with a coefficient of −1.778 ($p < 0.01$). The reason may be that, in the whole sample of 34 countries, 25 are from EU. In EU, many developed economies have a small population but are doing a large sum of trade with China. Physical distance between China and its trade partner has a significant negative relation with its bilateral trade, with a coefficient of −8.244 ($p < 0.01$), which indicates that the longer the distance, the less trade volume. Monetary freedom index and trade freedom index of China's trading partner show a significant positive impact on bilateral trade, with a coefficient of 0.487 and 1.757, respectively (both $p < 0.01$). The dummy variable WTO has a significant impact on bilateral trade

Table 6. Results of trade gravity model (the whole sample).

	OLS regression		GLS regression		fixed effect		random-effects	
Variable	Coefficient	t value	Coefficient	t value	Coefficient	t value	Coefficient	t value
lnGDPPit	.652***	3.23	.652***	3.26	.91	0.11	.555***	5.30
lnGDPPjt	1.062***	17.32	1.062***	17.46	.67***	7.92	1.185***	16.37
lnPOPit	−2.956	−0.55	−2.956	−0.55	−4.294	−0.02	−.249	−0.09
lnPOPjt	.909***	52.33	.909***	52.74	−1.778***	−7.07	.756***	10.48
lnDISCij	−2.471***	−20.71	−2.471***	−20.88	−8.244***	−14.79	−2.604***	−7.34
lnMONFjt	.612**	2.46	.612**	2.48	.487***	3.84	.529***	3.74
lnTRFRjt	1.07**	2.58	1.07***	2.60	1.757***	7.75	1.461***	5.86
WTOjt	.593***	3.80	.593***	3.83	.322***	3.64	.239**	2.43
lnHDIjt	−.813	−1.58	−.813	−1.59	1.952**	2.46	−2.049***	−2.79
_cons	71.536	0.64	71.536	0.65	180.403	0.04	22.358	0.39
R-squared	0.885		N/A		0.980		0.872	
Hausman test result					Prob > chi2 = 0.0000			
No. obs	646		646		646		646	

*** p<.01, ** p<.05, * p<.1.

with a coefficient of 0.322 ($p < 0.01$). Moreover, human development index has the highest positive impact on the trade flow between China and its trade partners, with a coefficient of 1.952 ($p < 0.05$). To sum up, our empirical results of the whole sample show that the bilateral trade flow between China and its trade partners are affected by trade partners' GDP per capita (positive), population (negative), distance (negative), monetary freedom (positive), trade freedom (positive), membership of WTO (positive), human development index (positive), yet China's GDP per capita and population have insignificant impact on the trade flow. Additionally, we find that trade freedom and human development index have the largest impacts (with a coefficient of 1.757 and 1.952 respectively) on trade flow among all the factors, which also indicates their vital importance to bilateral trade.

With our sub-sample data of China's trade with 9 ASEAN countries, the Hausman test result indicates that the random effect model is preferred. Thus, we mainly explain the random effect model results (Table 7). We find hat China's GDP per capita has a positive significant effect on China's bilateral trade flow with ASEAN countries, with a coefficient of 0.301 ($p < 0.1$), yet China's population has no significant impact. However, ASEAN countries' GDP per capita and population significantly and positively impact the bilateral trade flow between China and ASEAN, with a coefficient of 0.829 and 0.768, respectively (both $p < 0.01$). Physical distance has no significant impact on their bilateral trade. The monetary freedom and trade freedom of ASEAN countries have a significant positive impact on bilateral trade, with a coefficient of 0.48 and 1.208, respectively (both $p < 0.01$). The dummy variable WTO has a significant effect on China's trade flow with ASEAN, with a coefficient of 0.44 ($p < 0.01$). Moreover, the human development index has a high significant impact on the trade flow between China and ASEAN, with a coefficient of 1.459 ($p <$

Table 7. Results of trade gravity model (China's trade with ASEAN).

	OLS regression		GLS regression		Fixed effect		Random-effects	
Variable	Coefficient	t value	Coefficient	t value	Coefficient	t value	Coefficient	t value
lnGDPPit	.435*	1.70	.435*	1.75	5.948	0.46	.301*	1.71
lnGDPPjt	.632***	3.51	.632***	3.62	.838***	5.92	.829***	6.05
lnPOPit	−2.339	−0.36	−2.339	−0.37	−131.167	−0.43	.688	0.16
lnPOPjt	.745***	13.05	.745***	13.45	.333	0.48	.768***	4.92
lnDISCij	−.898***	−4.18	−.898***	−4.31	−4.645	−1.26	−1.027	−1.25
lnMONFjt	.487***	2.97	.487***	3.06	.379***	3.07	.48***	4.04
lnTRFRjt	1.159***	3.34	1.159***	3.44	1.372***	5.66	1.208***	5.01
WTOjt	.554***	5.03	.554***	5.19	.423***	5.28	.44***	5.49
lnHDIjt	2.739**	2.61	2.739***	2.69	1.195	1.32	1.459*	1.69
_cons	39.276	0.29	39.276	0.30	2742.532	0.43	−18.848	−0.22
R-squared	0.964		N/A		0.989		0.963	
Hausman test result					Prob > chi2 = 0.9918			
No. obs	171		171		171		171	

*** $p<.01$, ** $p<.05$, * $p<.1$.

Table 8. Results of trade gravity model (China's trade with EU).

	OLS regression		GLS regression		Fixed effect		Random-effects	
Variable	Coefficient	t value	Coefficient	t value	Coefficient	t value	Coefficient	t value
lnGDPPit	.828***	3.33	.828***	3.37	1.241	0.13	.681***	5.10
lnGDPPjt	.431***	4.66	.431***	4.71	.397***	2.81	1.191***	14.42
lnPOPit	−10.654*	−1.68	−10.654*	−1.70	−17.662	−0.08	−9.988***	−2.86
lnPOPjt	.778***	38.59	.778***	39.00	−1.368***	−3.77	.731***	9.55
lnDISCij	.726**	2.38	.726**	2.40	56.817***	6.80	−.27	−0.25
lnMONFjt	−.146	−0.25	−.146	−0.25	.864**	2.52	.743**	2.18
lnTRFRjt	1.888***	2.65	1.888***	2.68	1.713***	4.00	1.963***	4.76
WTOjt	1.298**	2.28	1.298**	2.30	.199	0.69	.477	1.55
lnHDIjt	10.022***	6.95	10.022***	7.03	11.102***	6.37	6.281***	3.96
_cons	162.318	1.24	162.318	1.26	−167.831	−0.04	164.732**	2.31
R-squared	0.899				0.979		0.860	
Hausman test result					Prob > chi2 = 0.0221			
No. obs	475		475		475		475	

***$p<.01$, **$p<.05$, *$p<.1$.

0.1). To sum up, China's population and its physical distance to ASEAN have no significant impact on their bilateral trade flow. As ASEAN countries are very near to China, the distance between them doesn't influence much their bilateral trade. Furthermore, ASEAN's GDP per capita (positive), population (positive), monetary freedom (positive), trade freedom (positive), WTO (positive) and human development index (positive) all have significant impacts on the bilateral trade between China and ASEAN. Additionally, among all the impact factors, trade freedom and human development index have the largest impacts, with a coefficient of 1.208 and 1.459, respectively, which also indicates their crucial importance to the bilateral trade.

With the sub-sample data of China's trade with 25 EU countries, the Hausman test result indicates that the fixed effect model is better. Thus, the fixed-effect model results are mainly explained (Table 8). It is found that both China's GDP per capita and population have no significant impact on China's bilateral trade with EU countries. EU's GDP per capita has a significant positive impact on the trade flow with China, with a coefficient of 0.397 ($p < 0.01$). EU's population has a significant negative relation with China's bilateral trade flow. Since EU is a highly developed economy and most countries have small population but high GDP per capita and strong purchasing power, the trade flow with China is high. It's interesting that the physical distance between China and its trade partners in EU has a significant and strong positive impact on China-EU trade. This is consistent with reality. China's main trading partners in the EU are high-income developed countries, which are mainly located in the west of the EU. They are farther from China than east EU countries, but they have large trade flows with China. Additionally, most west EU countries are close to the sea and have their sea ports, so the trade flow with China is very large despite long distance. We also find that the monetary freedom and trade freedom of EU countries both have a significant positive effect on China-EU bilateral trade, with a coefficient of 0.864 ($p < 0.05$) and 1.713 ($p < 0.01$). The WTO membership of EU has no significant impact on China-EU trade, and this may be because almost all EU countries have been WTO members since very early times. Furthermore, human development index has a significant strong impact on China-EU trade, with a coefficient of 11.102 ($p < 0.01$). To sum up, our empirical results indicate that China's GDP per capita and population and WTO membership of EU countries have no significant impact on China-EU trade; the significant impact factors are EU countries' GDP per capita (positive), population (negative), distance (positive), monetary freedom (positive), trade freedom (positive) and human development index (positive). Among all the factors, distance, human development index and trade freedom have the largest effects on China's bilateral trade flow with EU countries, which again proves the vital importance of trade freedom and human development index to bilateral trade.

VII. Conclusion

This article compares the bilateral trade between China-ASEAN and China-EU in terms of trade volume, trade structure, trade complementarity and impact factors of trade. The following are our findings.

Firstly, the comparison results of trade structure show that China mainly exports high-tech E&E and medium-tech products to ASEAN and high-tech E&E, low-tech and medium-tech manufactures to EU, yet China's imports from ASEAN mainly are high-tech E&E products (above 40%) and from EU are medium-tech products (40%). The reasons might be (1) EU limits the export of high-tech products to China, and some ASEAN countries may play the role of intermediaries to export to China; (2) China imports high-tech components and parts from ASEAN, assembles them into final products and then exports final products to ASEAN, EU and other countries. There is large trade volume (both exports and imports) between China and ASEAN in electronic and electrical area, which largely belongs to intra-industry trade and benefit both China and ASEAN.

Secondly, based on the RCA indexes of China's export products, we find that China has strong comparative advantages in low-tech manufacture area, increasing strong competitiveness in high-tech electronic and electrical area, comparatively

good competitiveness in medium-tech engineering area and weak competitiveness in primary, resource-based and medium-tech automotive and process manufactures. The changes of China's RCA index also show that China has an increasing competitiveness in more areas which reflects the trade creation and trade diversion effect. However, China also has an imbalanced development in its industrial structure with high competitiveness in low-tech and high-tech E&E area, low competitiveness in medium-tech area, which should be continuously improving and optimizing.

Thirdly, based on the TCI indexes we find (1) China has no trade complementarity with both ASEAN and EU in primary and resource-based manufactures as China has no comparative advantages in these two area; (2) China has high trade complementarity both with ASEAN and EU in low-tech manufactures yet China's trade complementarity of low-tech products is much higher with EU than with ASEAN. This is because in low-tech area, ASEAN also has comparative advantages like China and EU does not; (3) China medium-tech automotive and process manufacturers have no trade complementarity with ASEAN or with EU as China's comparative advantages in those two areas are weak, especially in automotive area; (4) China's trade complementarity is high with both ASEAN and EU in high-tech E&E area; however, China's trade complementarity in this area is much higher with ASEAN than with EU because EU has higher competitiveness than China and ASEAN.

Finally, from our structural gravity model of trade, we find some similarities and some interesting differences about the impact factors on China-ASEAN and China-EU trade. The similarities are the GDP per capita, monetary freedom, trade freedom and human development index of China's trade partners in ASEAN and EU all have significant positive impacts on bilateral trade; among all the factors, trade freedom and human development index have the largest impacts. The differences are (1) physical distance between China and ASEAN countries has no significant impact on their bilateral trade flow as China and ASEAN are close geographically; physical distance between China and EU has a significant positive effect and this is possibly because among the EU countries, China's actually have large trade flow with west EU countries which have more developed economy with high purchasing power and with convenient ports for large quantities of goods being transported by sea; (2) WTO membership has a significant impact on China-ASEAN trade, yet no significant impact on China-EU trade as most EU countries are already WTO members from early times and some ASEAN countries joined WTO late comparatively; (3) ASEAN's population has a significant positive impact on China-ASEAN trade, yet EU's population has a significant negative relation with China-EU trade. The reason possibly is that EU countries are highly developed. Even with small population, they have high GDP and strong purchasing power which result in large bilateral trade flow with China.

We find that the most vital and highly impacting factors on bilateral trade flow are trade freedom and human development index. This implies that free trade is critical for a country's trade growth and which in turn promote the country's economic development; moreover, with fast economic growth, the country's human development index can be increased and again boost economic growth and trade creation. Thus, it's very important for related policymakers to design more open trade policies to participate in the global labour division and take measures to improve their human development index.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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