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Trade Structure Change in the Asia-Pacific Region: Network Analysis of Trade Flow and Trade Agreements

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This study examines the relation between increasing trade agreements and trade flow performance in the Asia-Pacific region. Network analysis is employed to scrutinize the relationship between the two networks (the trade agreement and trade flow networks). Major findings are: 1) both networks in the region have expanded, and their relationships have deepened, 2) there is a positive correlation between the two networks, 3) the level of China's constraint on other countries increased, while Japan's status decreased in the trade network, 4) United States' status declined in the trade flow network, but its constraint power over primary agricultural trade increased.

Key words: Asia-Pacific region, trade structure, network analysis

1. Introduction

The expansion of international trade in the Asia-Pacific region and China's rapidly increasing presence through the regional trade flow has been receiving attention from researchers such as Hiratsuka (2006), Kawahara *et al.* (2011), Miyajima and Oizumi (2008). The number of free-trade agreements (FTAs) in the Asia-Pacific region has also increased and accumulated to 62 (JETRO, 2016). One important aspect of trade integration based on the realities of trade flow and institutional trade agreement in the region is that almost all the countries have become more deeply involved in the global economy. The economy of each country can be influenced not only by its direct trade partners but also by the partners' trade partners indirectly.

Foreign trade structure is an important economic determinant of *national power* that is the coercion power one nation may have against other nations (Hirschman, 1945). In fact, there have been cases wherein the trade restriction was used to coerce or influence other nations' political behavior in the region. Economic pressure through the trade relation mainly involves the threat of trade severance and the actual interruption of external economic relations with that country. The background of the changes of such national power should be understood related to the trade structural change as a whole in the region.

Generally speaking, FTAs (institutional trade integration) are expected to strengthen the trade relationships (real trade flow integration) between the contract parties. However, international trade research focusing on trade flow analysis has no way to grasp the trade structure multilaterally. Exceptionally, Nicolas (2010) scrutinizes the relationship between *de facto* (actual) and *de jure* (institutional) trade integrations in East Asia: ASEAN, China, Japan and Republic of Korea, and concludes that "*de facto* trade integration may not automatically lead to deeper regional trade cooperation *de jure*" (Nicolas, 2010: p.7, pp.24-25). It is not based on a quantitative analysis, however.

We empirically investigate the recent large change in the trade value flow and institutional connection in a holistic way and examine the change of national power in the Asia-Pacific region, a broader area including East Asia. As we explain below, the network analysis enable us to scrutinize the relationship between the two different networks in a consistent manner. In addition, taking indirect effects of trade partners into consideration for analysis, we clarify the change of the relationships of dependence among nations structurally.

2. Methodology

1) Network analysis

The network theory, which assumes that the structure of relationships can influence actors' behavior, provides several concepts useful to explore and interpret the complicated situation of networks (Granovetter, 1985). De Benedictis *et al.* (2013) firstly introduced 'network indices' such as 'degree centrality' and 'distance centrality' for estimating the national economic power in the international trade network. Other network indices such as 'density' and 'linkage' can show embeddedness to network, power to control and punish other actors, and institutional

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isomorphism (forced, mimetic, and normative).

According to Burt (1995) , an actor who can get a bird-eye view of the 'structural holes' (absence of connection) can increase 'autonomy' or 'constraint power' on the actors at the both endpoints of holes by utilizing a monopolistic status onto the information. Though the concept of 'structural constraint' that uses structural holes has not been often used for analyzing international trade (as a mere case, Okada (2003) investigated the autonomy of Turkmenistan), we employ this concept to explore the changing relative status of the nations in the complicated international trade networks.

2) Formulation

Using the concept of structural holes, actor j's structural constraint level on actor i is defined by the equation (1) (Burt, 1995).

$$C_{ij} = (P_{ij} + \Sigma_q P_{iq} P_{qj})(P_{ij} + \Sigma_q P_{iq} P_{qj}), \quad i \neq q \neq j, \quad (1)$$

where C_{ij} is j's structural constraint level on i (level of influential power of j on i), P_{ij} is j's share in i's all direct relations, $\Sigma_q P_{iq} P_{qj}$ is the total amount of indirect relations between i and j via q. Here q expresses all the actors other than i and j, meaning third parties.

C_{ij} is the product of two terms. The first term, $(P_{ij}+\Sigma_q P_{iq} P_{qj})$, consists of the shares of i's relations (including direct and indirect relations) in all the relations in the network. They are P_{ij}: the share of the relation between i and j in i's network, P_{iq}: the share of the relations between i and q in i's network and P_{qj}: the share of relations between q and j in q's network. This term represents the weighted sum of the time and energy of actor i spent to make the relation with actor j. This can be regarded as i's 'investment'. The more the investment increases, the more the investor, i, is constrained by its investment destination, namely, j.

The second term consists of, in fact, the same factors as the first term, however, the meaning is different. This term represents how j's behavior is constrained. Here $(P_{ij}+\Sigma_q P_{iq} P_{qj})$ indicates the total amount of j's relations with all the other actors in the network from the perspective of i. It represents the level of the lack of structural holes around j (see Figure 1) [1]. As it increases, the total amount of j's relation in the network becomes bigger or the structural holes around j decreases. It means that j can behave more autonomously and advantageously to i. Therefore j's constraining power on i increases.

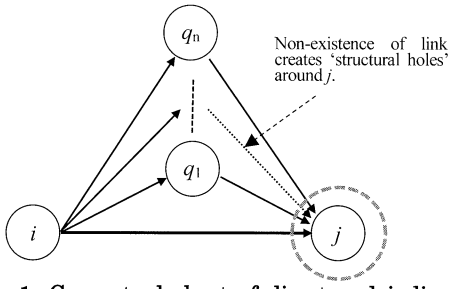

Figure 1. Conceptual chart of direct and indirect linkages from i to j via q: $q_1 \ldots q_n$ and structural holes around j

Based on the equation (1), we calculate C_{ij} in the trade agreement network (= $SCFTA_{ij}$: Structural Constraint level in the FTA network). P_{ij} is the number of FTAs in force between i and j weighted by the total of FTAs between i and all its partners. $\Sigma_q P_{iq} P_{qj}$ is the total of indirect relations between i and j via q. Here, q is the third parties, namely, all the actors other than i and j. $\Sigma_q P_{iq} P_{qj}$ is the total of P_{iq} (the numbers of FTAs in force between i and q weighted by the total number of FTAs between i and all its partners) multiplied by P_{qj} (the numbers of FTAs in force between q and j weighted by the total FTA number between q and all its partners). The larger $SCFTA_{ij}$ becomes, the bigger the structural constraint in the FTA network between two parties becomes, and vice versa.

Regarding the trade (export and import) flow networks, we calculate C_{ij} (=$SCTrade_{ij}$: Structural Constraint level in the trade flow network) in the similar steps, using P_{ij} (direct trade share between i and j in i's total trade value) and $\Sigma_q P_{iq} P_{qj}$ (the total amount of indirect trade between i and j via q). The larger $SCTrade_{ij}$ in export flow network (i is an exporter to j and j is an importer to i) becomes, the bigger j's structural constraint level as an importer to i becomes, and vice versa. The larger $SCTrade_{ji}$ in import flow network (i is an exporter to j and j is an importer to i) becomes, the bigger i's structural constraint level as an exporter to j becomes, and vice versa.

Furthermore, *SCTrade* is compared with trade intensity (*TI*), which is an often used index to represent the direct trade connectivity between countries. It is measured by the equation (2).

1) The second term can be multiplied by O_j (internal constraint of j) in the case where j is not a single actor but a group consisting of plural actors and the actor's behavior is constrained by its internal structure. In this study, however, all the actors are single countries and no country-group such as ASEAN is included. Therefore, O_j is not applied, or assumed to be 1 (Burt, 1995: p. 64).

$$TI_{ij} = (X_{ij}/X_i)/(X_j/(X-X_i)) \quad (2)$$

where TI_{ij} is the trade intensity between countries i and j, X_{ij} is the export value from country i to country j, X_i is the total export value from country i, X_j is the total export value to country j, X is the world total of export value.

3) Data

APEC member countries are chosen for this study. We added India to the subject, considering its importance. Due to the availability of trade information, the research focus is finally placed on 20 countries in the Asia-Pacific region: Australia, Canada, Chile, China, Hong Kong, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, Peru, Philippines, Rep. of Korea, Singapore, Taiwan, Thailand, the Russian Federation, USA, and Vietnam. Trade figures are collected from UN COMTRADE's BEC data (Total; Category 1, food and beverages; Category 11, primary; and Category 12, processed). The following section discusses the change of network scores from the year 2000 to 2014.

3. Relationship between the Trade Flow and Trade Agreement Networks

1) Changes of the structural constraints in the two networks

The relation between the change of the trade (export and import, total value) flow network and the change of the trade agreement network is discussed here. The change of bi-lateral country relations is expressed in Figure 2. The location of each dot represents the change level of one nations' constraint level on another nation from the year 2000 to 2014. The location on X-axis ($\Delta SCFTA_{ij}$) is the difference of C_{ij} in the FTA network and the location on Y-axis ($\Delta SCTrade_{ij}$) is the difference of C_{ij} in the trade flow network. Major findings are as follows:

(1) Many dots in the first quadrant of the two scatter diagrams indicate the relations between the countries and China. This means that China's constraint power on the other countries increased based on the realities of trade and institutional trade arrangements.

(2) Most dots indicating the relations with Japan are plotted in the third and fourth quadrants of the diagrams. This means that Japan as an importer and an exporter lost its constraining power in the trade flow network.

(3) The relations with USA are mostly plotted in the third quadrant. This means that USA lowered its constraining power in both the trade flow network and trade agreement network.

(4) Most other relations are located around the X-axis, whether their institutional constraint was weakened or strengthened.

The above observation on the mutual relationship between the changes in constraint level in both the trade agreement network and the trade flow network is statistically examined. The estimation results of regression equations are as follows:

$$\Delta SCTrade_{ij} = 1.0625 * \Delta SCFTA_{ij} \quad R^2 = 0.0475 \quad (3)$$

(t-statistic = 4.346)

$$\Delta SCTrade_{ji} = 1.1514 * \Delta SCFTA_{ji} \quad R^2 = 0.0458 \quad (4)$$

(t-statistic = 4.266)

where the equation (3) expresses the change of importer j's constraint on exporter i and the equation (4) expresses the change of exporter i's constraint on importer j.

The coefficients of determination of the above equations are low but significant. The regression coefficients for $\Delta SCFTA$ are positive and significant. Therefore, it is concluded that the changes in constraint level in the two networks in the Asia-Pacific region have a weak and positive correlation. However, this relation is mostly based on the changes of the three countries, China, Japan and USA. As to the other countries, their *SCTrade* did not change largely despite the changes of their *SCFTA*. This finding is similar to Nicolas (2010)'s conclusion that points a weak relation between *de facto* trade integration and trade cooperation *de jure* in East Asia (Nicolas, 2010: p.7).

2) Status changes of Japan, China, USA, and Thailand

To examine the changes of the two networks in more detail, we select four countries and show their *TI* and network indices (*SCFTA* and *SCTrade*) and so on in Table1. Japan, China and USA are chosen because their huge status changes contribute to the positive correlation between the changes of the two networks. Thailand is chosen as a representative of the rest 17 countries, which did not change their status largely in the trade flow network, because of its relative importance in the both networks[2].

Japan moderately decreased its constraint level in the FTA network, *SCFTA*, from 0.248 to 0.236, while its constraint level in the trade flow network, *SCTrade*, of total

2) Thailand occupies 5% of the agricultural export in the region in 2014 (the third largest of the 17 countries). In addition, the total sum of its FTAs and its partners' FTAs is 60 (the second largest). The agricultural exports of Canada and Australia are bigger than the Thai export but their status in the FTA network is relatively low. The total numbers of their FTAs and their partners' FTAs are 23 and 33 respectively.

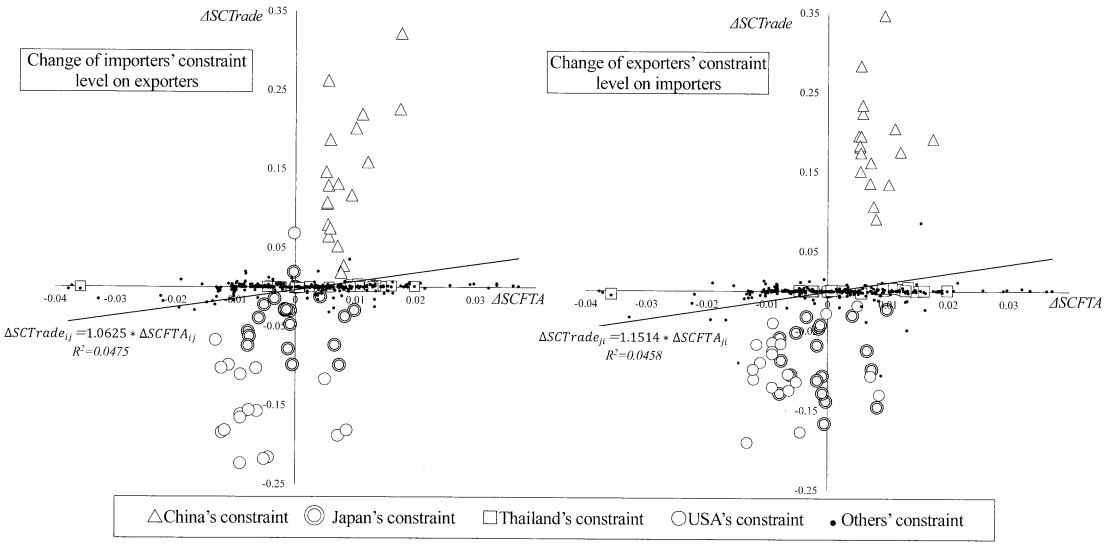

Figure 2. The relation between the change of constraint in the trade flow network (export/import flow network) and the change of constraint in the trade agreement network

Source: Authors' calculation using BEC classification data of UN COMTRADE: Category Total.

Notes: 1) X-axis: $\Delta SCFTA_{ij}$ represents the change of j's constraint level on i in the trade agreement network between 2014 and 2000. 2) Y-axis: $\Delta SCTrade_{ij}$ represents the change of country j's constraint level on i in the trade flow network. 3) The location of each dot (there are totally 380 dots, every combination patterns of pairs from the 20 countries) represents the change of constraint level from one country to each of the other countries in the two networks. For instance, the location of marker △ represents the difference of China's constraint level on the other countries in terms of the trade flow and trade agreement networks between 2014 and 2000.

trade decreased both as an exporter from 2.329 to 0.683 and as an importer from 1.564 to 0.722. *TI* of total trade increased from 1.96 to 2.00 as an exporter and decreased from 2.23 to 2.17 as an importer. Japan decreased its power to constrain other countries at the stage of international trade in the region despite its *TI* increasing in export. As to agricultural trade, it decreased both *TI* and *SCTrade* as an exporter and importer.

China largely increased *SCFTA* from 0.00 to 0.221. It also greatly increased *SCTrade* in terms of total and agricultural trade. In contrast, it decreased *TI* of total and agricultural trade. China increased its constraining power in the region in terms of both institutional and real trade networks.

USA decreased *SCFTA* from 0.251 to 0.209. It increased *TI* of total trade but decreased *SCTrade* both as an exporter and as an importer. As to agricultural trade, it also decreased *SCTrade*. In total USA decreased its constraining power in the region, while it became more strongly connected to the region.

Thailand moderately increased *SCFTA* from 0.246 to 0.264. The *SCTrade* of total trade in terms of both export and import increased; however, *TI* of import decreased. As to agricultural trade, it decreased *TI* and *SCTrade* as an exporter but increased *TI* and *SCTrade* as an importer.

This observation describes the change in Japan's position more clearly than looking only at *TI* indexes. Similarly, judging from the change of *TI*, USA increased its connectivity with Asia-Pacific countries though its power to constrain them decreased as indicated by the change of *SCTrade*. In contrast, the constraint level from China as an export partner increased though the *TI* indexes decreased as an exporter. In sum, the network approach provides clearer observations by adding new information to the trade *TI* index analysis.

3) Food and beverages trade of the four countries

Lastly, we scrutinize the status change of the four countries in the food and beverages trade flow network (Category 1, 11, and 12 in Table 1) because of its importance in the interest of national security as well as energy. Generally, the status change in the agricultural trade flow network is similar to that in the total trade flow network. China increased its presence, while the other

countries decreased or remained at a low level of their presence. Japan decreased its status remarkably (import share in Category 1 decreased from 26% to 12%, *SCTrade* decreased 5.103 to 1.227).

However, USA's status as a primary goods exporter seems to be maintained exceptionally. In export part of Category 11, USA slightly increased its share from 30% to 32% and increased *SCTrade* score from 7.149 to 7.536, which means that the change in primary material trade flow network gave USA fortified power to control other Asia-Pacific countries.

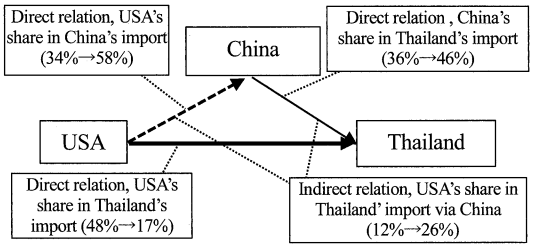

Figure 3. Change of direct and indirect trade shares of the three countries in Category 11 (2000→2014)

Source: Authors' calculation

Note: See Figure 1.

Table 1. Changing status of Japan, China, USA, and Thailand in trade flow and trade agreement networks

	year	trade[1] value	trade[2] share	*TI*[3]	*SCFTA*[4]	*SCTrade*[5]		year	trade[1] value	trade[2] share	*TI*[3]	*SCFTA*[4]	*SCTrade*[5]
Japan							**USA**						
export							export						
Total	2000	361.0	16%	1.96	0.248	2.329	Total	2000	509.0	22%	3.30	0.251	4.479
	2014	545.0	8%	2.00	0.236	0.683		2014	1022.0	16%	4.07	0.209	2.666
Category1	2000	1.7	2%	6.39	0.248	0.055	Category1	2000	28.8	28%	3.55	0.251	5.195
	2014	3.8	1%	5.77	0.236	0.015		2014	91.9	26%	3.75	0.209	4.822
Category11	2000	0.3	1%	12.01	0.248	0.014	Category11	2000	12.1	30%	3.28	0.251	7.149
	2014	0.9	1%	5.58	0.236	0.004		2014	43.9	32%	2.78	0.209	7.536
Category12	2000	1.4	2%	6.80	0.248	0.116	Category12	2000	16.7	27%	3.89	0.251	4.126
	2014	3.0	1%	5.89	0.236	0.025		2014	48.0	22%	5.00	0.209	3.461
import							import						
Total	2000	240.0	10%	2.23	0.248	1.564	Total	2000	809.0	35%	2.85	0.251	6.625
	2014	494.0	8%	2.17	0.236	0.722		2014	1563.0	24%	3.51	0.209	3.897
Category1	2000	26.3	26%	2.83	0.248	5.103	Category1	2000	27.3	27%	4.08	0.251	4.456
	2014	41.7	12%	2.54	0.236	1.227		2014	77.6	22%	4.42	0.209	3.513
Category11	2000	9.9	24%	2.81	0.248	5.469	Category11	2000	11.6	28%	3.99	0.251	3.957
	2014	13.0	10%	2.54	0.236	1.226		2014	30.7	23%	4.64	0.209	3.439
Category12	2000	16.4	27%	3.14	0.248	4.660	Category12	2000	15.7	26%	4.51	0.251	4.436
	2014	28.6	13%	2.85	0.236	1.333		2014	46.8	22%	4.84	0.209	3.693
China							**Thailand**						
export							export						
Total	2000	184.0	8%	2.79	0.000	0.699	Total	2000	50.0	2%	2.22	0.246	0.060
	2014	1545.0	24%	1.93	0.221	4.423		2014	160.0	2%	2.28	0.264	0.077
Category1	2000	9.5	9%	4.33	0.000	0.411	Category1	2000	6.8	7%	2.44	0.246	0.446
	2014	44.6	13%	3.23	0.221	1.432		2014	17.3	5%	2.02	0.264	0.203
Category11	2000	3.2	8%	4.65	0.000	0.499	Category11	2000	2.2	5%	2.84	0.246	0.327
	2014	16.2	12%	3.95	0.221	1.783		2014	4.4	3%	2.79	0.264	0.059
Category12	2000	6.2	10%	4.27	0.000	0.408	Category12	2000	4.6	8%	2.52	0.246	0.614
	2014	28.3	13%	3.05	0.221	1.257		2014	13.0	6%	2.17	0.264	0.358
import							import						
Total	2000	169.0	7%	5.23	0.000	0.699	Total	2000	43.0	2%	2.70	0.246	0.039
	2014	1113.0	17%	3.38	0.221	3.323		2014	150.0	2%	2.60	0.264	0.056
Category1	2000	6.2	6%	10.73	0.000	1.076	Category1	2000	1.1	1%	3.15	0.246	0.027
	2014	53.2	15%	2.09	0.221	2.147		2014	8.4	2%	3.52	0.264	0.093
Category11	2000	3.3	8%	5.08	0.000	1.138	Category11	2000	0.4	1%	2.41	0.246	0.014
	2014	29.1	21%	2.01	0.221	3.020		2014	3.0	2%	3.72	0.264	0.059
Category12	2000	2.9	5%	21.78	0.000	1.079	Category12	2000	0.6	1%	4.55	0.246	0.029
	2014	24.0	11%	3.05	0.221	1.637		2014	5.4	2%	3.85	0.264	0.103

Source: Authors' calculation using BEC classification data of UN COMTRADE: Category Total; Category 1, food and beverages; Category 11, primary; Category 12, processed.

Notes: 1) Billion US$. 2) Trade share is each country's trade value in the sum of the trade value of 20 countries. 3) Trade intensity (*TI*) is the sum of the respective country's *TI* figures with other 19 countries weighted by each country's trade share. 4) *SCFTA* is the sum of the respective country's constraint level on other 19 countries in the trade agreement network. 5) *SCTrade* is the sum of the respective country's constraint level on other 19 countries in the trade flow network.

Figure 3 describes the change of trade share from USA to Thailand via China. USA's share in China's import increased from 34% to 58%, while USA's share in Thailand's import decreased from 48% to 17%. China's share in Thailand's import increased from 36% to 46%. Therefore, indirect export share from USA to Thailand via China increased from 12% to 26%. While USA decreased direct export share in the import of Thailand, it increased indirect export share to Thailand, as USA increased direct export share to China and China increased direct relations to Thailand, though actually traded goods are quite different between these two trade relations. For example, USA mainly exports grain to China and Thailand while China exports vegetables to Thailand. 10 countries (Canada, Indonesia, Japan, Mexico, New Zealand, Philippines, Rep. of Korea, Taiwan, Thailand, and the Russian Federation) decreased USA's direct trade share and increased USA's indirect trade share via China in the same way. This process decreased structural holes around USA and increased the *SCTrade* of USA in Category 11.

TI of USA increased largely in Category 1, while *TI* as an exporter in Category 11 decreased and its connectivity has become stronger outside than inside the Asia-Pacific region.

4. Conclusion

Employing the network analysis, this study empirically investigated the recent large change in the trade flow and institutional connection in a holistic way and examined the relative status change of nations in the Asia-Pacific region, considering direct and indirect relations among nations.

Firstly, by computing the level of influential power among nations, the relationship between the change of institutional network and the change of real trade network was scrutinized in a consistent manner. It verified Nicolas (2010)'s conclusion that points a weak relation between *de facto* trade integration and trade cooperation *de jure*, as to many countries in the region except China, Japan and USA.

In addition, the detailed examination of 'network indices' (*SCFTA* and *SCTrade*) of the four countries shows each countries' distinguishing characteristic of status change. In particular, we clearly indicate the increase of the influential power of China and the decrease of the power of Japan and USA not only in the trade flow network, but also in the FTA network. As to the trade of agricultural products, it is pointed out that USA has kept its high status in the trade network of primary agricultural goods mostly because of the indirect relation with many Asia-Pacific countries via China.

On the other hand, Japan has lowered its status as an importer of agricultural products significantly. It means that Japan has been facing tougher competition in importing agricultural and fishery products. In order to secure enough food supply to the population, Japan should take necessary measures such as the diversification of food import partners and the improvement of the domestic ability to produce food.

Important factors such as foreign direct investment and exchange rate are not involved in this study. Study of the influence of these elements remains for further research.

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