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The Cross-strait Industrial Chains between Taiwan and Mainland China

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Abstract

Since the 1990s, cross-strait production cooperation has strengthened in conjunction with the development of Taiwanese investment in the Mainland. This paper first investigates the formation of cross-strait industrial chains, subsequently studies their types and structures through an analysis of the cross-strait intra-industrial trade and industrial divisions of 816 HS4 coded industries in the period 2004-2012, and finally proposes policy suggestions to strengthen cross-strait industrial cooperation. The results indicate that cross-strait industrial chains formed in 299 of 816 industries in 2012, which accounted for 41.28% of total trade, and 68.56% of those industry chains were characterised as vertical division with Taiwan superiority.

Keywords: Taiwanese investment; intra-industry trade; vertical and horizontal division; cross-strait industrial chain

I. Introduction

Taiwan has been hailed as the fourth leading electronic industrial “kingdom” in the world and produces more than ten types of IT products that rank first in the world market. Two of Taiwan’s industries, i.e., liquid crystal displays (LCD) and semiconductor components, were ranked in second place and fourth place in the world respectively, and 75% of personal computers were produced by Taiwanese manufacturers in 2005. However, most of these products are not manufactured in Taiwan. According to estimates from the Taiwan Institute for Information Industry, IT products manufactured abroad accounted for 93% of total Taiwanese IT products in 2005, 80% of which were manufactured in Mainland China (Yin, 2006). A similar situation appears in many other industries. The proportion of Taiwanese products manufactured on the Mainland has increased consistently since the 1990s. Cross-strait industrial chains and industrial divisions have gradually formed with the development of the cross-strait manufacture of Taiwanese products and the cross-strait layout of Taiwanese industries.

These cross-strait industrial chains are important constituents of the East Asian production network. In the twenty-first century, the East Asian production network has become the largest manufacturing base in the world. In recent years, Mainland China has become the largest manufacturing centre and the largest export platform in East Asia, such that the “bilateral trade” of this network’s exports to the world market has become a “triangular trade” network via the

Chinese Mainland (Tang and Zhang, 2008; Lin and Deng, 2012).

In addition to global manufacturing fragmentation and regional economic integration, the development of cross-strait industrial chains has also been driven by the development of cross-strait relationships. In 1979, the Mainland announced its political desire for peaceful unification across the Taiwan Strait and began to promote cross-strait economic and cultural exchange by increasing direct cross-strait links in postal, air and shipping services and trade (referred to as the “Three Direct Links”) to normalise the cross-strait economy and trade exchange. Through these concerted efforts, Taiwan and the Mainland established close economic relationships. Taiwanese investment in the Mainland and cross-strait trade has developed rapidly. The “Three Direct Links” became a reality in 2008, and two-way investment was realised in 2009 with the Mainland company gaining permission to invest in Taiwan. In 2010, Taiwan and the Mainland signed the *Cross-Strait Economic Cooperation Framework Agreement* (ECFA). With the process of economic amalgamation brought about by the policy of “Economy First, Politics Later”, cross-strait industrial chains formed, which represent not only a phased achievement of peaceful cross-strait reunification but also the foundation for further cross-strait economic cooperation. Since 2009, the Cross-Strait Industrial Cooperation group, organised by experts from both sides, has sought policies to promote reasonable industrial division and industrial layout between the two sides. The aim of this group is to avoid overlapping investment and industrial competition between the two sides and to deepen cross-strait industrial chain cooperation.

Currently, few studies in the literature have addressed cross-strait economic cooperation from the perspective of the industrial chain. Among examples of research on the subject, Duan Xiaomei (2010) calculated the intra-industry trade (IIT) indices of the cross-strait electronic product trade and analysed the types of trade observed. Li and Wu (2010) investigated the intra-industry trade in the cross-strait agricultural product trade and empirically researched the factors influencing that trade. Hua and Zheng (2010) calculated and analysed cross-strait intra-industry trade in 21 sections (HS system) of products. However, these studies either analysed the intra-industry trade between the two sides with respect to a single industry or calculated intra-industry trade using data from rough classifications. To date, there are no studies in the literature on cross-strait industrial chains.

Our study attempts to systematically investigate the formation and the structure of the cross-strait industrial cooperation. This paper first discusses the Taiwanese investment in the Mainland and the formation of cross-strait industrial chains in section II, then analyses their structures by calculating the intra-industry trade indices (IIT) of 816 HS4 industries and the GHM indices of 2004-2012 in section III, and finally draws conclusions and policy implications in section IV.

II. Taiwan’s Business Investment in the Mainland and the Formation of the Cross-Strait Industrial Chains

Attracted by the Mainland’s open-door policy and the low cost of labour, Taiwanese began to invest in the Mainland in the 1980s. Initially, small-scale investments from Taiwan’s labour-intensive manufacturing industries (i.e., textile manufacturing, clothing, shoemaking and metal processing) appeared in the Pearl River Delta and Fujian area. Next, after Mr Deng Xiaoping’s South Inspection Speech in 1992, the Taiwanese investment entered a second stage

during which large enterprises from high-tech manufacturing industries began to invest, the investment scales increased, and the investment area expanded to the Yangtze Delta. During this period, Taiwanese industries shifted to the Mainland on a large scale. After 2010, Taiwanese investment entered the third stage. Investments began to shift to the service industry and to the west and north of the Mainland. By the end of 2013, Taiwanese investment in the Mainland accounted for up to 133.68 billion dollars¹, primarily in such sectors as the manufacture of electronic components, computers, electronic and optical products, and electrical equipment (see the structural changes to investment in Table 1).

Table 1. Industrial Structure of the Taiwanese Investment in the Mainland (Unit: %)

Item/Year	1991	1995	2000	2005	2007	2010	2012	2013	1991 -2013
Agriculture	0.00	0.20	0.22	0.13	0.17	0.05	0.07	0.02	0.22
Industry	99.89	92.18	92.28	89.02	88.82	75.08	59.35	56.68	80.59
Manufacturing	99.37	91.39	91.45	87.93	87.92	74.16	58.78	55.72	79.71
Food	11.03	9.98	1.24	0.78	0.64	1.36	1.14	1.37	2.21
Textiles Mills	12.35	5.39	1.56	2.47	1.04	0.78	0.58	0.07	1.66
Rubber Products	18.34	3.36	0.42	1.79	0.98	0.48	0.72	0.58	0.98
Plastic Products	9.80	5.56	7.00	4.15	5.85	2.84	1.44	2.03	4.02
Fabricated Metal Products	5.26	9.49	5.30	9.03	3.10	2.79	1.59	1.84	4.51
Electronic Parts and Components	2.87	9.32	15.82	14.15	24.33	33.21	15.23	11.17	19.08
Computers, Electronic and Optical Products	8.00	5.05	26.80	20.70	16.93	8.45	11.90	12.78	13.74
Electrical Equipment	7.26	6.52	16.40	9.33	10.50	4.67	3.42	5.01	7.32
Services	0.11	7.62	7.50	10.85	11.01	24.87	40.58	43.29	19.19
Wholesale and Retail Trade	0.11	5.14	2.22	4.57	4.13	7.63	9.94	11.27	5.97
Financial and Insurance	0.00	0.01	0.00	0.58	1.18	3.42	13.49	20.68	4.67

Source: Calculated according to relevant data from “Investment Commission, MOEA of Taiwan”.

Taiwanese investment in the Mainland established links for industries on both sides and facilitated the formation of cross-strait industrial chains. The investment enterprises purchased raw materials, components and semi-finished products from their Taiwanese parent companies for production and sold the products back to Taiwan, as indicated in tables 2 and 3. In 2002, 44.98% of the raw materials, components and semi-finished products required by Taiwanese investment enterprises were purchased in Taiwan, and 69.19% of their products were sold back to Taiwan. However, the two figures decreased to 27.21% and 14.20% in 2012 respectively, alongside Taiwanese investment. This situation occurred because the Taiwan up- and down-stream complementary enterprises continuously invested in the Mainland and Taiwanese investment enterprises purchased the materials they required locally. In other words, a component of the Taiwan industrial chain shifted to the Mainland. The convergences of the two figures in table2 and table3 meant that the stable cross-straits industry relationship formed. In the primary industries for

¹ The data are taken from “Investment Commission, Ministry of Economic Affairs, Taiwan”.

Taiwanese investment such as electronic parts and components computers, electronic and optical products, the purchase rates between Taiwanese investment enterprises and their parent companies still remained at high level in 2012. This indicated that Taiwanese investment play a critical role in the formation of cross-straits industrial chains.

Table 2. Rates of the Taiwanese Investment enterprises' Purchase of Raw Materials, Components and Semi-finished Products from Taiwan (Unit: %)

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Overall average	44.98	39.37	34.00	34.38	36.94	32.69	31.03	30.15	27.72	26.59	27.21
Electronic Parts and Components	—	—	27.90	59.67	47.15	43.55	33.39	32.98	34.32	34.38	32.10
Computers, Electronic and Optical Products	—	—	42.08	13.25	43.31	44.11	39.79	41.80	34.22	39.42	38.69
Machinery and Equipment	—	—	13.00	22.79	22.86	25.61	21.77	27.43	28.48	20.75	22.21
Fabricated Metal Products	—	—	58.06	34.60	29.77	15.94	28.68	26.67	20.54	26.33	28.50
Plastic Products	38.75	49.99	55.68	55.16	13.51	17.82	41.11	26.40	24.80	26.16	29.58

Source: Arranged according to relevant items from 2003-2007 "Survey and Analysis Report on Operation Performance of Taiwanese Firms in the Mainland" and 2008-2013 "Survey and Analysis Report on Operation Performance of Overseas Taiwanese Firms", from "Investment Commission, MOEA".

Note: 2002-2007 data include machinery and equipment.

Table 3. Rates of the Taiwanese Investment enterprises' Products Sold Back to Taiwan (Unit: %)

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Overall average	69.19	21.96	23.44	26.17	12.60	21.06	17.94	16.92	17.47	16.07	14.20
Electronic Parts and Components	—	—	36.05	26.61	26.50	26.39	26.30	24.37	30.78	24.17	26.03
Computers, Electronic and Optical Products	—	—	46.51	72.29	13.64	27.42	30.68	32.13	35.19	26.52	34.30
Machinery and Equipment	—	—	27.59	25.52	8.40	19.94	15.54	10.04	10.53	9.04	5.10
Fabricated Metal Products	—	—	22.26	5.25	3.75	25.87	11.43	10.02	8.69	14.65	12.11
Plastic Products	96.95	0.22	0.40	0.87	0.19	11.18	6.38	9.76	15.25	10.54	5.91

Source: Same as Table 2.

Taiwanese investment enterprises also established close supply chain cooperation with Mainland enterprises in recent years. A survey conducted by Li Baoming (2012) revealed that nearly half (48.4%) of Taiwanese investment enterprises in the Mainland engaged in close cooperation with Mainland enterprises in major businesses. The internal supply chains among Taiwanese enterprises were broken. Some Taiwanese investment enterprises outsourced all or a portion of their manufacturing to Mainland enterprises and concentrated themselves on marketing and export promotion. Most Taiwanese investment enterprises cooperated with Mainland enterprises to develop the domestic market.

Taiwanese investment enterprises are pioneers that promote the formation of supply chain relationships between enterprises on both sides of the strait and maintain these relationships. In the electronics display industry, eight colour TV enterprises (TCL, Skyworth, Hisence, Konka, Changhong, Xocoeco, Haier and Panda) on the Mainland purchased LCDs (up to 100 million pieces), totalling a value of 25.7 billion dollars from Taiwanese enterprises over six successive years.² In the laptop industry, the Mainland enterprise Lenovo purchases approximately 4 billion dollars' worth of electric components from Taiwanese enterprises annually. For example, in August 2009, the Lenovo Group signed purchase contracts totalling 3.255 billion US dollars for laptops and flat-panel displays (FPD) with many Taiwanese companies, among which Wistron, Quanta, Palmax, AUO, Foxconn and Chi Mei received 1 billion, 700 million, 600 million, 400 million, 200 million and 120 million dollars from the contracts, respectively.³ In the mobile phone industry, Xiaomi (a Mainland mobile phone company) has a close relationship with Taiwanese industries, from component manufacture to assembly. TJD supplies most of Xiaomi's components, OKWAP and Foxconn assist Xiaomi in assembly, and Lite provides display technology.⁴

Taiwanese investments are typically regarded as an extension of Taiwan industry on the Mainland. However, from the perspectives of place of registration and the location of production activity, Taiwanese investments are a constituent of the Mainland industries. Taiwanese investments' imports and exports are counted in the Mainland trade. In addition to direct contributions to trade across the Taiwan Strait, Taiwanese investments also drive the development of Mainland trade with other countries and areas. According to Li Baoming and Liu Zhentao (2004), each dollar of Taiwanese investment contributed a 0.713 dollars increase in cross-strait trade, of which 0.583 dollars were imported from Taiwan and 0.13 dollars were exported to Taiwan. The trade effects of Taiwanese investment vary across industries. Significant trade effects have taken place due to investment in such industries as plastics, metal manufacturing, machinery and electrical equipment, and precision appliances in addition to indistinct trade effects in the traditional industries of food and beverages.

Over the past twenty years, cross-strait trade volumes increased rapidly, expanding from 7.41 billion dollars in 1992 to 197.28 billion dollars in 2013, an increase of nearly 26 times and equivalent to an average annual growth rate of 17.8%. The Mainland is currently Taiwan's largest trade partner, largest export destination, and largest source of trade surplus. Taiwan is now the seventh-largest trade partner and the fifth-largest source of imports for the Mainland. Most of the cross-strait trade is in machinery, semi-finished products, components and parts, indicating the formation of cross-strait industrial chains.

The cross-strait trade figures prominently in the rapid development of Asian intra-regional trade. The proportion of the cross-strait trade in the Asian intra-regional trade increased from 1.3% in 1991 to 5.61% in 2012, indicating that cross-strait industrial chains play an important role in the Asian industrial network.

III. Structure and Types of Cross-Strait Industrial Chains: The Trade Perspective

² Sixth Purchasing to Taiwan: Changes of Rising of China Panel Industry. www.fpdisplay.com, 2013-06-27.

³ Yang Shumin: Three Delegates of Foreign Trade Federation Going to Taiwan for Purchase and Signing: Lenovo Ordered at 3.255 Billion Dollars. www.fjsen.com, 2009-08-24.

⁴ Wen Yaqiong: Xiaomi President: A Close Combination of Xiaomi Mobile and Taiwan Industrial Chain. www.chinanews.com, 2013-09-27.

1. Research Methods and Data Sources

Two approaches are available for analysing the formation of industrial chains between two countries or areas. One approach analyses the trade in parts and component rates, and the other approach analyses intra-industry trade. In this study, we adopt the latter approach, which consists of two steps.

The first step determines whether intra-industry trade exists between Taiwan and the Mainland. In this study, we use the following equations (1)-(4) (Bergstrand, 1983) to calculate the cross-strait intra-industry trade index (IIT index).

$$\bar{G}_{tm}^{k*} = \sum_{k=1}^n S_k \times G_{tm}^{k*} \dots\dots\dots (1)$$

$$G_{tm}^{k*} = 1 - \left[\left(\left| X_{tm}^{k*} - X_{mt}^{k*} \right| / (X_{tm}^{k*} + X_{mt}^{k*}) \right) \right] \dots\dots\dots (2)$$

$$X_{tm}^{k*} = 1/2 \left[(X_t + M_t) / 2X_t + (X_m + M_m) / 2M_m \right] \times X_{tm}^k \dots\dots\dots (3)$$

$$X_{mt}^{k*} = 1/2 \left[(X_m + M_m) / 2X_m + (X_t + M_t) / 2M_t \right] \times X_{mt}^k \dots\dots\dots (4)$$

where \bar{G}_{tm}^{k*} is the weighted average index of the cross-strait intra-industry trade that measures the overall status of cross-strait intra-industry trade; G_{tm}^{k*} denotes the cross-strait intra-industry trade index of industry k; S_k is the proportion of the trade volume of industry k in the total trade volume between the two sides; X_{tm}^{k*} and X_{mt}^{k*} are the adjusted Taiwanese export and import volumes of industry k to and from the Mainland, respectively; X_{tm}^k and X_{mt}^k are the Taiwanese export and import volumes of industry k to and from the Mainland, respectively; X_t and M_t are the Taiwanese total export and import volumes, respectively; X_m and M_m are the Mainland's total export and import volumes, respectively; and n denotes the number of industries.

The IIT index takes values on the interval [0, 1]. The closer the IIT index is to 1, the greater the extent to which cross-strait intra-industry trade has formed as a whole or a single industry. Taking 0.5 as the threshold value, we hold that if the IIT index is greater than 0.5, the cross-strait trade is intra-industry trade; otherwise, it is not intra-industry trade or it is inter-industry trade. We hold that a cross-strait industrial chain forms in an industry in which intra-industry trade forms.

The second step is to determine the type of intra-industry division in the industrial chain, i.e., vertical or horizontal. In this study, Greenaway's method is used to calculate the GHM index as shown in equation (5) (Greenaway, 1995).

$$GHM_i = UV_{ik}^x / UV_{ik}^m \dots\dots\dots (5)$$

where GHM_i is the index of the intra-industry division type of industry i; UV^x is the unit price of Taiwanese export commodities to the Mainland, UV^m is the unit price of Taiwanese import commodities from the Mainland, and k denotes the trade partner. According to Greenaway (1995), if $1 - \alpha \leq GHM_i \leq 1 + \alpha$, then the industry is considered to have a horizontal

intra-industry division; if $GHM_i > 1 + \alpha$, then it is considered to have a vertical intra-industry division with superiority; if $GHM_i < 1 - \alpha$, then it is considered to have a vertical intra-industry division with inferiority, where α is a scatter factor and takes the value 0.25 or 0.15.

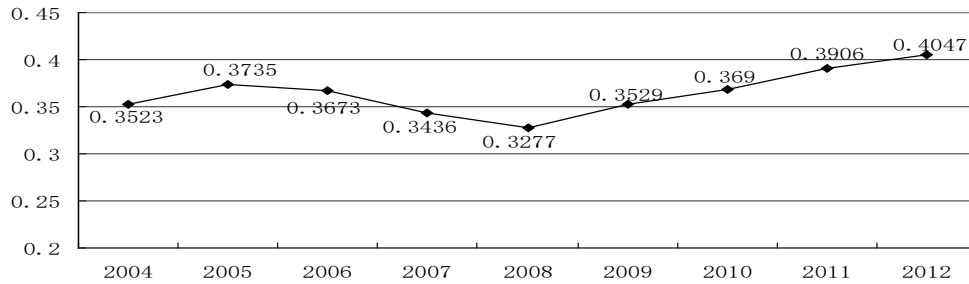
The cross-strait trade volume data and trade quota data for 2004-2012 from 1261 industries in the HS4 bit code were acquired from the Customs Administration, Ministry of Finance, Taiwan. The price data are calculated by dividing the trade volume data by the trade quota data. For mathematical convenience, certain industries with zero imports or exports in a given year were removed, and 816 industries remained. The trade volume of these 816 industries accounts for more than 95% of total trade volume in every year of the period 2004-2012. Thus, we can ignore the removed industries.

2. The Cross-strait Industrial Chains

According to equations (1)-(4), the IIT indices of 816 industries and their weighted average indices are calculated and reveal the following features.

First, the weighted average index \bar{G}_m^k was less than 0.5 with a maximum value of 0.4047 in 2012, as shown in Figure 1, meaning that overall cross-strait trade was characterised as inter-industry trade. Additionally, the \bar{G}_m^k decreased from 0.3735 in 2005 to 0.3277 in 2008 and subsequently increased steadily to 0.4047 in 2012, which indicates a high possibility that cross-strait intra-industry trade would form within the next several years.

Figure 1. Weighted Average IIT Indices of Cross-strait Trade During 2004-2012



Second, from an individual industry perspective, the IIT indices of 299 industries were greater than 0.5 in 2012, which accounted for 36.64% of the total 816 industries (as shown in Figure 2), i.e., cross-strait intra-industry trade (or a cross-strait industrial chain) formed in 299 industries in 2012. From a dynamic perspective, from 2004 to 2012 (reported in Table 4), the IIT indices of 452 industries increased, among which the IIT indices of 152 industries changed from below 0.5 (inter-industrial trade) to greater than 0.5 (intra-industry trade). The IIT indices decreased for a total of 364 industries, among which the IIT indices of 106 industries changed from greater than 0.5 (intra-industry trade) to below 0.5 (inter-industry trade). The industries exhibiting intra-industry trade increased from 253 (31%) in 2004 to 299 (36.64%) in 2012. Conversely, the industries exhibiting inter-industry trade decreased from 563 (69%) in 2004 to 517

(63.36%) in 2012.

Figure 2. Changes in Industry Quantity and Proportion of Cross-strait Intra(Inter)-Industry Trade during 2004-2012

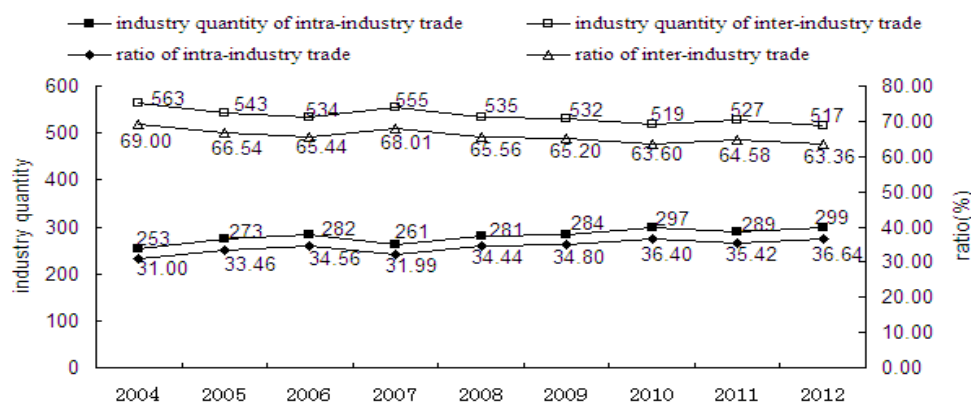


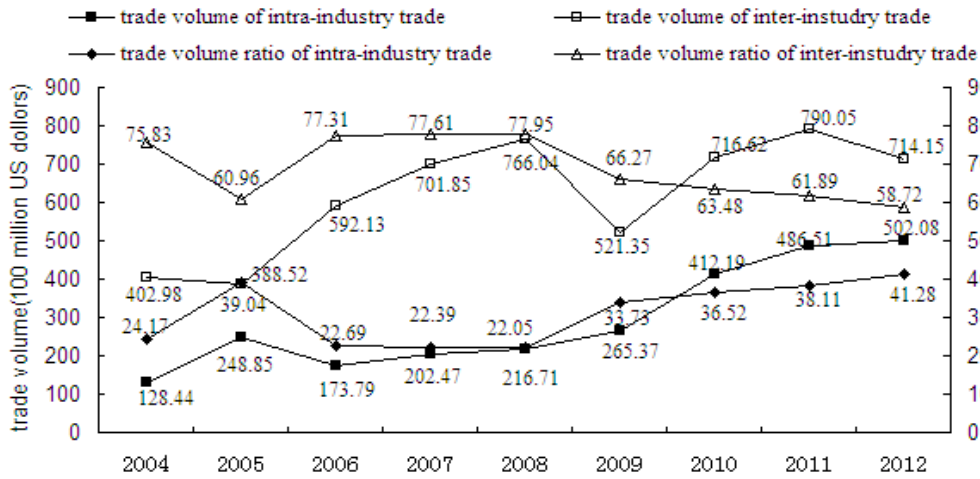
Table 4. IIT Index Changes for 816 Industries from 2004 to 2012

Item / change	Industries with an increasing IIT index			Industries with a decreasing IIT index		
	Still in inter-industry trade	From inter-industry to intra-industry trade	Still in intra-industry trade	Still in intra-industry trade	From intra-industry to inter-industry trade	Still in inter-industry trade
Quantity of industry	231	152	69	78	106	180
Ratio (%)	28.31	18.63	8.46	9.56	12.99	22.06

From a trade volume perspective (Figure 3), the total volume of industries exhibiting intra-industry trade increased from 12.844 billion dollars in 2004 to 50.268 billion dollars in 2012, and the corresponding proportions grew from 24.10% to 41.28%. Moreover, the trade volumes of industries exhibiting inter-industry trade also increased from 40.298 billion dollars to 71.415 billion dollars, but the corresponding proportion declined from 75.83% to 58.72%.

Therefore, at the individual industry level, a striking trend indicates that cross-strait trade was developing into inter-industry trade.

Figure 3. Changes in the Volume and Ratio of Cross-strait Intra (Inter)-Industry Trade during 2004-2012



Third, in six major chapters of cross-strait trade, the IIT indices of HS85, HS84 and HS72 were greater than 0.5 and increased steadily over the period 2004-2012, meanwhile those of HS90, HS39 and HS29 were below 0.5. This finding indicates that intra-industrial trade formed in categories HS85, HS84 and HS90, and inter-industrial trade formed in categories HS90, HS39 and HS29. The trade volume of the six categories accounted for nearly 80% of the entire trade volume, which IIT indices are listed in Table 5.

HS85 contains electronic machinery and equipment (and components thereof), sound recorders and reproducers, television images and sound recorders/reproducers, and components and accessories of such articles. In the cross-strait trade, these products primarily consist of electronic and related products. In 45 industries of this chapter, 28 exhibited intra-industry trade, equating to a share of 62.22%, in 2012.

H84 includes nuclear reactors, boilers, machines, and mechanical appliances (and components thereof). In the cross-strait trade, these items primarily consist of machines and related products. This chapter exhibits a high degree of intra-industry trade. In 81 industries of this chapter, 40 exhibited intra-industry trade, equating to 49.38%, in 2012.

Table 5. IIT Indices of Major Categories of Cross-strait Trade During 2004-2012

Chapter	2004	2005	2006	2007	2008	2009	2010	2011	2012
HS85	0.6543	0.6847	0.6944	0.6681	0.6643	0.7288	0.7394	0.8030	0.7893
HS90	0.2575	0.2343	0.2418	0.1957	0.1796	0.1981	0.1823	0.2385	0.2042
HS84	0.8223	0.8131	0.7600	0.8114	0.8957	0.9860	0.7853	0.8381	0.8707
HS39	0.1667	0.1851	0.1870	0.1730	0.1820	0.1724	0.1684	0.2065	0.2228
HS29	0.2553	0.2323	0.2715	0.1929	0.2009	0.2189	0.3336	0.2900	0.3100
HS72	0.7783	0.6811	0.8412	0.8354	0.7221	0.6184	0.7040	0.7988	0.9190

HS72 consists of iron and steel industries and also exhibited a high degree of intra-industry trade. In 23 industries of this chapter, 7 exhibited intra-industry trade, equating to 30.43% in 2012.

HS90 contains precision instruments and related products, including optical, photographic, cinematographic, measuring, assessment, precision medical/surgery instruments and apparatuses, clocks and watches, musical instruments, and components and accessories thereof. This category constantly demonstrated a high degree of inter-industry trade in the period from 2004 to 2012. In 32 industries of this chapter, 17 exhibited intra-industry trade, equating to 53.12% in 2012.

HS39 includes plastics and articles thereof. This chapter also exhibited a high degree of inter-industry trade in the period from 2004 to 2012. In its 26 industries, 12 were intra-industry trade, equating to 46.15% in 2012.

HS29 includes organic chemicals and exhibited inter-industry trade from 2004 to 2012. In its 35 industries, 13 were intra-industry trade, equating to 37.14%, in 2012.

3. The structures and types of Cross-strait Industrial Chains

Using equation (5), we calculate the GHM indices of the industries exhibiting intra-industry trade as determined in Section 3.2. Setting the scatter factor $\alpha = 0.25$, we classify the industries into three categories. The first category is cross-strait horizontal division (denoted by H) if $0.75 \leq GHM_i \leq 1.25$. The second category is cross-strait vertical division with Taiwanese superiority (denoted by V_T) if $GHM_i > 1.25$. The third category is cross-strait vertical division with Taiwan inferiority (or Mainland superiority) (denoted by V_M) if $GHM_i < 0.75$. In this study, GHM denotes Taiwan's superiority to the Mainland. The larger the GHM, the greater is Taiwan's superiority in the industrial division between the two sides. The results are reported in Table 6.

(1) In general, vertical division with Taiwan superiority (V_T) is dominant in the cross-strait industrial chains. As reported in Table 6, the quantity of industries and trade volumes of V_T were 205 pieces and 39.21 billion dollars, which accounted for 68.56% and 78.11% of the cross-strait industrial chains, in pieces and volume respectively, in 2012. However, the proportions of vertical division with Mainland superiority (V_M) in industry quantity and trade volume were 12.04% and 6.24%, and the proportions of horizontal division (H) in industry quantity and trade volume were 19.4% and 15.65%. From 2004 to 2012, there was an obvious trend towards the expansion of V_T and a decline in V_M and H, meaning that Taiwan's industries were consistently moving to the upstream side of the cross-strait industrial chains.

Table 6. Different Types of Intra-Industry Division between the Two Sides during 2004-2012
(Units: Piece, 100 million US dollars,%)

Year/ Item	V_T				V_M				H			
	Quantity of industries	Quantity ratio	Trade volume	Volume ratio	Quantity of industries	Quantity ratio	Trade volume	Volume ratio	Quantity of industries	Quantity ratio	Trade volume	Volume ratio
2004	163	64.43	95.31	74.21	41	16.20	8.63	6.71	49	19.37	24.50	19.08
2005	178	65.20	113.54	45.63	40	14.65	13.52	5.43	55	20.15	121.8	48.94
2006	196	69.50	118.60	68.24	36	12.77	12.89	7.42	50	17.73	42.30	24.34
2007	178	68.20	132.20	65.29	41	15.71	41.93	20.71	42	16.09	28.34	14.00
2008	180	64.06	147.60	68.11	42	14.94	34.58	15.96	59	21.00	34.53	15.93
2009	200	70.42	205.84	77.57	43	15.14	40.16	15.13	41	14.44	19.37	7.30
2010	204	68.69	309.11	74.86	37	12.45	28.25	6.84	56	18.86	75.58	18.30
2011	195	67.47	380.11	78.13	38	13.15	30.48	6.26	56	19.38	75.92	15.61

2011	195	67.47	380.11	78.13	38	13.15	30.48	6.26	56	19.38	75.92	15.61
2012	205	68.56	392.15	78.11	36	12.04	31.36	6.24	58	19.40	78.57	15.65

(2) From a dynamic perspective, V_T strengthened steadily in recent years. We compare the GHM changes of 405 industries with which were of intra-industry trade in 2004 or 2012. Table 7 indicates that the GHMs of 226 industries increased with changes in the type of trade structure from V_M to H in 20 industries, V_M to V_T in 27 industries, H to V_T in 41 industries, V_M to V_M in 11 industries, H to H in 19 industries, and V_T to V_T in 108 industries. Additionally, the GHM values decreased for 179 industries with changes in the type of trade structure from V_T to H in 29 industries, V_T to V_M in 17 industries, H to V_M in 7 industries, H to H in 7 industries, V_M to V_M in 18 industries, and V_T to V_T in 101 industries. Through this comparison, we observe increases in V_T not only in quantity but also in quality.

Table 7. Changes in the GHM Index of Industries from 2004 to 2012

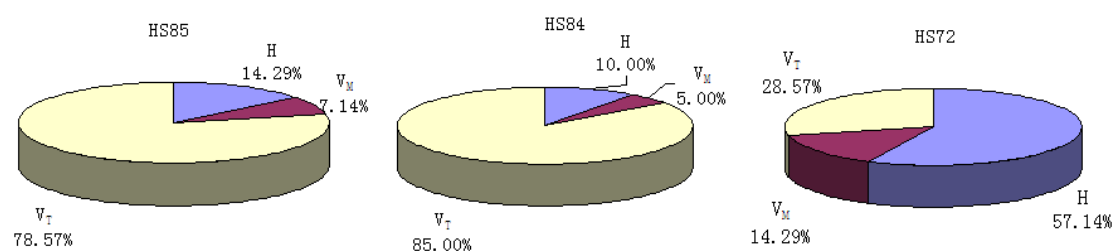
Industries with GHM increasing	Type Change	Industry quantity	Ratio	Industries with GHM decreasing	Type Change	Industry quantity	Ratio
226	$V_M \rightarrow H$	20	4.94	179	$V_T \rightarrow H$	29	7.16
	$V_M \rightarrow V_T$	27	6.67		$V_T \rightarrow V_M$	17	4.2
	$H \rightarrow V_T$	41	10.12		$H \rightarrow V_M$	7	1.73
	$V_M \rightarrow V_M$	11	2.72		$V_T \rightarrow V_T$	101	24.94
	$H \rightarrow H$	19	4.69		$H \rightarrow H$	7	1.73
	$V_T \rightarrow V_T$	108	26.67		$V_M \rightarrow V_M$	18	4.44

(3) In the major chapters of intra-industrial trade, HS85 and HS84 were vertical division with Taiwanese superiority (V_T), and HS72 was cross-strait horizontal division (H) in 2012. The cross-strait trade structures of their industries (HS 4 bit code) are analysed as shown in Table 8 and Figure 4.

Table 8. Industrial Division in the Industries of Major Chapters

Chapter	V_T	V_M	H
HS85	22 industries: 8501; 8502; 8504; 9505; 8511; 8512; 8515; 8517; 8522; 8526; 8527; 8529; 8532; 8533; 8535; 8536; 8537; 8538; 8539; 8542; 8546; 8547	2 industries: 8523; 8543	4 industries: 8503; 8525; 8531; 8544
	34 industries: 8409; 8411; 8412; 8413; 8414; 8416; 8417; 8419; 8421; 8424; 8430; 8431; 8432; 8433; 8436; 8438; 8440; 8446; 8447; 8448; 8449; 8452; 8453; 8454; 8467; 8468; 8470; 8473; 8474; 8476; 8480; 8481; 8482; 8484	2 industries: 8405; 8469	4 industries: 8442; 8443; 8445; 8475
HS72	2 industries: 7204; 7205	1 industry: 7226	4 industries: 7210; 7216;

Figure 4. Distribution of Industrial Division Types in HS85, HS84 and HS72



In HS85, 4 industries were horizontal (H), 22 industries were vertical with Taiwan superiority (V_T), and 2 industries were vertical division with Mainland superiority (V_M) in 2012, accounting for 14.29%, 78.57% and 7.14%, respectively. From a dynamic perspective, vertical structures with Taiwan superiority (V_T) increased and vertical structures with Mainland superiority (V_M) decreased.

In HS84, 4 industries were horizontal (H), 34 industries were vertical with Taiwan superiority (V_T), and 2 industries were vertical with Mainland superiority (V_M) in 2012, accounting for 10%, 85% and 5%, respectively. From a dynamic perspective, horizontal (H) and vertical structures with Mainland superiority (V_M) increased, and vertical structures with Taiwan superiority (V_T) declined.

In HS72, 4 industries were horizontal (H), 2 industries were vertical with Taiwan superiority (V_T), and 1 industry was vertical with Mainland superiority (V_M) in 2012, accounting for 57.14%, 28.57% and 14.29%, respectively. From a dynamic perspective, the horizontal structure (H) increased and the vertical structure with Taiwan superiority (V_T) declined.

Based on the above analysis, we obtained the following results: (1) of 816 industries, 299 exhibited intra-industry trade in 2012, which accounted for 36.64% of industry quantity and 41.28% of trade volume and displayed a rising tendency in the period from 2004 to 2012; (2) of 299 industries of intra-industry trade, 205 industries were vertical division with Taiwan superiority (V_T), 36 industries were vertical division with Mainland superiority (V_M) and 58 industries were horizontal division (H) in 2012, which accounted for 68.56%, 12.04% and 19.40% of industry quantity and 78.11%, 6.24% and 15.65% of trade volume, respectively. This result highlights the prominence of vertical division with Taiwan superiority (V_T) in cross-strait industrial cooperation; (3) of the major chapters of cross-strait trade, HS85 (electromechanical & electronic industries) and HS84 (mechanical industries) were vertical division with Taiwan superiority (V_T) and HS72 (iron and steel) was horizontal division (H) in 2012.

IV. Conclusions and Policy Implications

From the 1980s on, Taiwanese investment in the Mainland has driven the gradual development of cross-strait trade and cross-strait industrial cooperation in vertical or horizontal directions (i.e., industrial chains). The empirical analysis reveals that 299 of 816 industries established industrial chain relationships in 2012, which accounted for 36.64% of industry quantity and 41.28% of trade volume. In these industrial chains, more than 2/3 are characterised by vertical structure with Taiwan superiority, and less than 1/3 belong to the cross-strait horizontal division or vertical

division with Mainland superiority. Regarding the major industries of cross-strait trade, the electromechanical and electronics and mechanical industries have exhibited a vertical structure with Taiwan superiority, and the iron and steel industry has exhibited a cross-strait horizontal structure. This study also indicates that the industries in which cross-strait industrial chains have formed are those in which Taiwanese investments have been focused. Thus, the development of a cross-strait industrial chain depends on the development of Taiwanese investments and may fluctuate with the investment to a certain extent.

Stable cross-strait industrial chains are beneficial to cross-strait economic relationships and the development of the East Asia production network. To avoid overlapping investment, industrial competition, and the breakdown of cross-strait industrial chains, both sides of Taiwan and Mainland should initiate industrial policy coordination. In the industries characterised by a vertical structure with Taiwan superiority, Taiwan should constantly update its aspects of the cross-strait industrial chains by increasing R&D investment, whereas the Mainland should increase the scale of downstream production based on its huge market and manufacturing capacity. In the industries characterised by a horizontal cross-strait structure, both sides should exploit their respective advantages to promote collaborative development. To ensure close cooperation in the industrial chain, it is necessary for the upstream and downstream manufacturers of both sides to form stable demand-supply relationships through beneficial integration, i.e., cross-shareholding holdings, a mechanism for risk and benefit sharing. Regarding the high OEM shares of American and European companies in the cross-strait industrial chain, both sides must also strengthen R&D and brand development via joint investment. In addition, Taiwanese business development on the Mainland should receive continual attention and support.

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