

Special Feature A

Asia's Electronics Supply Chains and Global Trade Corridors

1 Introduction

Over the past half century, Asia has grown into a global manufacturing powerhouse alongside the export-oriented industrialisation process adopted by many countries. The region's dominance in manufacturing activity is most evident in the electronics industry, where it currently accounts for two-thirds of global production. The conjunction of a liberal global trade system and the cross-border deployment of production nodes by comparative advantage across the electronics value-added chain have given rise to the proliferation of electronics supply chains in the region. At the same time, China has expanded and upgraded its manufacturing capabilities rapidly since the 2000s and now lies at the centre of production chains. However, the country's rising labour costs over the past decade have induced significant and ongoing shifts in these chains. Since 2018, this reconfiguration process has been accelerated by heightened trade tensions between the US and China, resulting in the imposition of additional tariffs on Chinese exports. Given the strong inter-connectedness of electronics production in Asia, the trade frictions have implications for China, as well as for the region as a whole.

This Special Feature aims to assess the impact of the US-China trade conflict on regional as well as global patterns of electronics trade, focusing particularly on the US' demand for electronics goods produced by Asia's China-centric production network. It is divided into two main parts: in the first, the electronics trade corridors prior to the onset of the US-China tensions are described. The global and regional trade flows in intermediate and final electronics goods as well as supporting services are presented, alongside the rise of Vietnam as a key node. The second part assesses how electronics supply chains have shifted since the implementation of the additional US tariffs on China's products. The impact of the tariffs on countries' market shares in electronics imports to the US is considered, as well as their indirect effects on the suppliers of electronics inputs. Finally, the driving factors underpinning future trends in the electronics supply chains in Asia and US-Mexico are briefly discussed.

2 Pre-tariff Electronics Trade Corridors

To characterise the regional electronics supply chain and its impact on trade flows, the framework shown in **Figure 1** is used. The final demand for electronics goods in a given economy can be fulfilled by domestic producers or via imports, i.e., foreign suppliers. In turn, these producers will require intermediate inputs, which can similarly be purchased from domestic suppliers or foreign firms. The supply chain in turn gives rise to trade flows along well-established global and regional corridors, as described below. Based on this framework, the electronics linkages and corresponding trade flows across Asia are analysed using trade

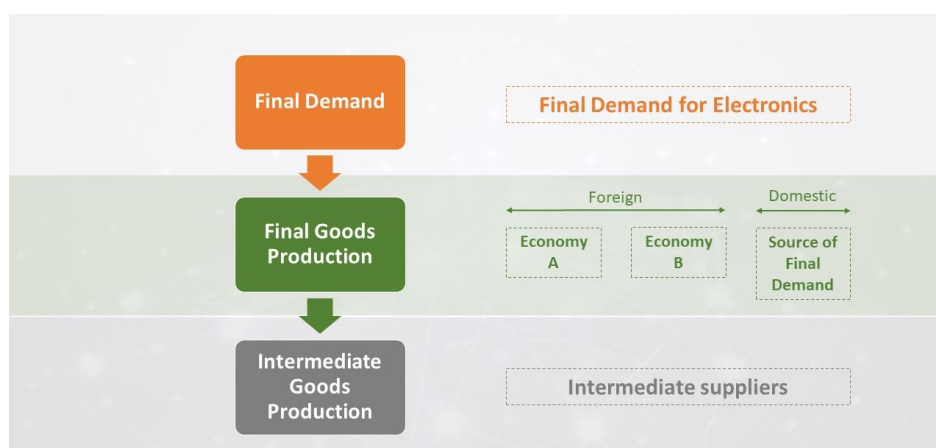
data extracted mainly from the UN Comtrade database down to the 4-digit level over the period 2007–2017.¹

US and China Final Demand

In terms of final demand, China is the largest market for electronics products, with a global share of 20% in 2015, followed by the US, with a share of 17%. Nevertheless, reflecting China's larger role as a global manufacturer of such products, only one-third of its demand for final electronics goods is satisfied by imports, compared with more than two-fifths for the US. Indeed China is the top exporter of electronics products, including personal computers (PCs), mobile phones, hard disk drives (HDD) and parts for PCs, accounting for at least half of global exports (excluding re-exports) for the first two categories. As such, China is an important import source of both final electronics products and intermediate components for the Asian countries and the US. In the case of the European Union (EU), China is a major supplier of mainly final products.

Of its total imports of final electronics goods, the US sources about 60% from China and another one-fifth from Mexico. Supplies from China are mainly mobile phones and PCs while imports from Mexico comprise computer central processing units (CPU) and TVs, in addition to mobile phones. Notably, China accounts for almost all of the US' PC imports. As for China, reflecting its domestic production capabilities in a range of a final electronics goods, its imports are mainly peripherals including HDDs from Thailand, the Philippines, South Korea and Taiwan, as well as audio/visual-related products from Vietnam, South Korea, Japan and the EU.

Figure 1 Electronics supply chains



Intermediate Goods Trade Flows

Integrated circuits (ICs) are the building blocks of electronics products. With electronics production concentrated in Asia, there has been a sharp pickup in IC trade within the region in the last decade. In particular, China is one of the largest global suppliers of ICs with its share almost doubling to about 18% in the span of a decade. At the same time, China is also the largest market for ICs globally, with its imports almost three times its exports. It exports

¹ The UN Comtrade data is supplemented with a more detailed breakdown of Singapore's trade flows provided by Enterprise Singapore. Some data series are available only up to 2016, including Hong Kong SAR's re-exports.

ICs to Taiwan and South Korea, but also purchases eight times and five times more ICs from them respectively.

Taiwan is the largest global exporter of ICs with a slightly higher share than China's, and is the main supplier to China, Japan, Malaysia and Thailand as well as a major source for the Philippines and South Korea. South Korea ranks on par with China in terms of IC exports and is the largest source for Vietnam and the Philippines. The two firms dominating world high-end IC design and manufacturing are Taiwan Semiconductor and the South Korean firm, Samsung. As a result, the shares of Taiwan and South Korea in China's overall intermediate electronics imports are considerable at 25% and 22% respectively (Figure 2 and Table 1).

Figure 2 China's sources of intermediate electronics inputs (2017)

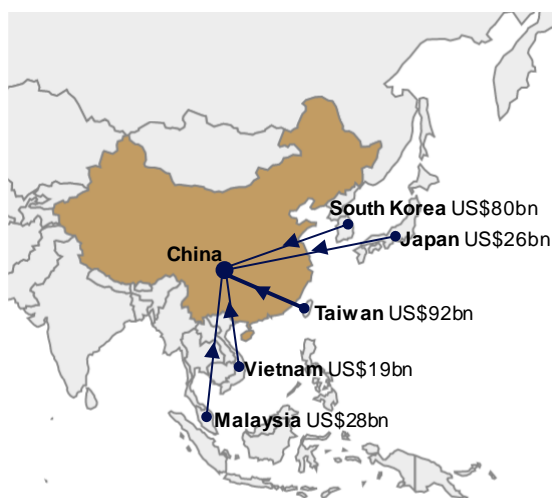


Figure 3 Mexico's sources of intermediate electronics inputs (2017)

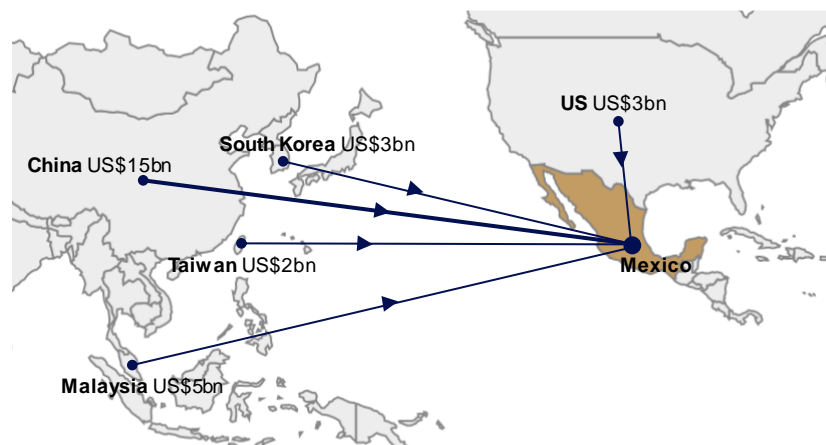
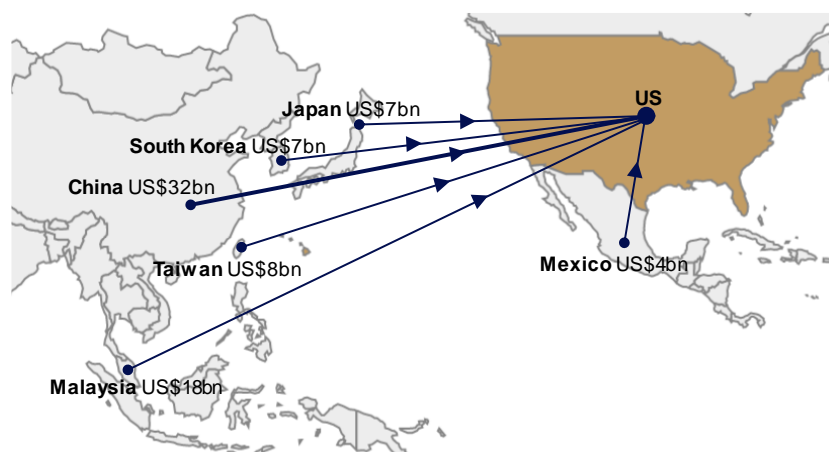


Figure 4 US' sources of intermediate electronics inputs (2017)²

In contrast, Japan accounts for only 7% of China's imports of intermediate electronics components. Indeed, Japan registered declines in exports of various electronics products in the past decade. Notably, its global market share of ICs is now only half of what they were just a decade ago. Over the same period, the global share of South Korea's exports of mobile phones likewise slumped from about 15% to less than 5%. Consequently, Japan is no longer the main source of ICs for South Korea and Taiwan, and the electronics supply chain linkages among the Northeast Asian economies (outside of China) have weakened considerably.

The ASEAN economies collectively account for a modest 20% of China's total imports of intermediate electronics inputs, with 8% from Malaysia alone. Specifically, Malaysia has a substantial share of 9% in China's IC imports and is also an important source of mobile phone parts. In addition, Thailand, the Philippines and Malaysia are major suppliers of HDDs to the production network centred on China, given the presence of the top global manufacturers including Western Digital, Seagate, Hitachi and Toshiba in the ASEAN region. Indeed, the three economies collectively account for more than 60% of China's HDD imports, with a third from Thailand.

Linkages among some ASEAN economies, namely Indonesia, Malaysia, Singapore, Thailand and the Philippines, have weakened somewhat with the emergence of China as the global electronics production centre. In particular, Singapore used to be a major source of both electronics components and final products for the region but has since ceded market share to China. However, these ASEAN countries traditionally have close industry ties that continue to result in considerable trade in components. For example, Singapore is the second largest source of ICs for Malaysia (after Taiwan) and Indonesia (after China). Malaysia also imports parts from Singapore and Thailand for its production of reader machines, which command a global share of about 15%. Similarly, Thailand sources ICs from Malaysia for its production of HDDs which accounts for about 18% of global exports.

Over at the US-Mexico supply chain, Mexico sources most of its intermediate electronics inputs from Asia despite the geographical distance (**Figure 3 and Table 1**). This reflects Asia's comparative advantage in the production of such inputs. China supplies 70% and 60% of Mexico's imports of PC parts and mobile phone components respectively, while Malaysia and China are the largest sources of ICs with a combined share of more than 50%, followed by

² An estimated 38% of the US' imports of intermediate electronics inputs are re-exported.

another 8–9% each from South Korea and Taiwan. Similarly, the US imports most of its intermediate inputs for domestic production of electronics final goods from Asia, especially China and Malaysia (Figure 4 and Table 1).

Rise of Vietnam

Among the Asian economies, Vietnam has seen the greatest intensification of electronics industry linkages with China, due to its adoption of a “China plus 1” production model. China outsources the production of electronics peripherals as well as components, notably headphones/earphones and PC parts, to Vietnam. These are mainly in the form of investments by small and medium-sized enterprises (SMEs) specialising in providing electronics manufacturing services (EMS). China is also sourcing more ICs from foreign semiconductor plants set up in Vietnam. As a result, China’s intermediate imports from Vietnam grew at a staggering 72% per annum (p.a.) in the last decade even as it seeks to increasingly source for inputs domestically. Accordingly, Vietnam’s share of China’s imports of intermediate electronics goods rose from near zero in 2007 to 5% in 2017.

Apart from China, South Korea’s electronics industries are also closely linked to Vietnam’s. South Korea has become one of Vietnam’s largest investors with companies such as Samsung and LG setting up production facilities in the country to tap on its proximity to China as well as its low-cost base. The companies specialise in the manufacture of mobile phones as well as intermediate parts using components and ICs imported from South Korea. The phones are then exported to end consumer markets while the parts are forwarded to China or sent back to South Korea for assembly into final products. As a result of these linkages, South Korea is now the largest source of ICs and second largest source of mobile phone components for Vietnam, as well as the second largest market for Vietnam’s exports of mobile phone parts.

With investments from China, South Korea and the US, Vietnam has seen phenomenal growth in its exports of mobile phones and printers/photocopiers in the past decade. Its share in world production of mobile phones at less than 10% is far below China’s 50% and the EU’s 20%, but is already almost on par with the US. Vietnam has also carved out a similar global share in exports of printers/photocopiers, overtaking Japan and the US.

Table 1 Trade in intermediate electronics products (2017)

US\$ Billion	Destination Economy:												
	USA	MXN	CHN	JPN	KOR	TWN	HKG	SGP	MYS	PHL	THA	VNM	
Source Economy:													
USA		2.5	12.0	3.4	4.4	4.4	5.1	2.5	6.0	2.3	1.8	2.8	
MXN	4.4		3.1	0.2	0.2	0.1	0.3	0.2	0.1	0.0	0.0	0.2	
CHN	31.9	14.8		11.9	17.3	15.2	88.9	11.3	7.0	2.3	3.0	12.3	
JPN	6.9	1.5	26.2		4.8	7.1	11.8	3.7	2.8	3.1	3.3	3.1	
KOR	7.4	2.8	80.2	2.7		7.8	23.8	10.5	1.6	3.3	0.9	17.0	
TWN	7.5	2.1	91.8	11.2	11.0		34.3	21.1	8.1	3.3	3.3	3.8	
HKG	0.2	0.1	0.7	0.0	1.1	0.1		0.4	0.9	0.9	0.1	0.4	
SGP	1.6	0.5	8.0	1.1	2.3	3.8	26.8		6.2	1.7	1.0	0.6	
MYS	18.0	5.3	28.2	1.6	2.0	2.4	11.0	12.7		0.6	1.9	0.6	
PHL	3.1	0.9	9.9	1.5	1.2	1.3	7.8	4.7	1.0		1.2	0.4	
THA	2.3	0.8	7.5	1.3	0.7	0.7	4.1	1.8	1.4	0.6		0.8	
VNM	3.6	1.3	18.8	0.4	4.0	0.5	4.9	0.6	1.5	0.2	0.2		

Source: UN Comtrade and EPG, MAS estimates

Vietnam's linkages with other ASEAN economies are modest compared to its ties with the Northeast Asian countries. Singapore was the only notable import source among them and accounted for one-fifth of Vietnam's electronics imports in 2007. However, this proportion fell significantly over the last decade to just 1.5% in 2017. Singapore previously supplied more than one-third of Vietnam's IC imports and almost half of PC imports, but Vietnam has switched to sourcing these products from South Korea and China, respectively.

Intermediary Role of Hong Kong and Singapore

In the regional trade in electronics products and components, Hong Kong and Singapore perform special roles as intermediary trade hubs. Due to its geographical proximity and extensive economic ties with China, Hong Kong has established itself as the redistribution hub for electronics exports, largely intermediate goods, to and from China. As a result, Hong Kong was able to grow its electronics re-exports by an average of 7.3% p.a. over 2007–16. It handles about 40% of China's IC trade and is the key gateway to China from the other Northeast Asian economies: Taiwan and Korea each route about a quarter of their ICs through Hong Kong while the proportion for Japan is about 15%. Consequently, Hong Kong has taken the top spot in global exports of ICs (almost entirely re-exports), overtaking Singapore since 2009. Indeed, Hong Kong's IC re-exports have now grown to 1.8 times those of Singapore.

In addition, most of China's imports of parts for office machines and mobile phone components are via Hong Kong. Overall, Hong Kong's re-exports to China constitute a considerable 44% of China's total electronics imports. As for China's exports to the rest of the world, the proportion that is shipped through Hong Kong is much lower at 24% and it has fallen from the peak of 30% in 2013. For example, China now exports about 20% of mobile phones through Hong Kong, compared to 40% previously.

Singapore acts primarily as a distribution centre for exports of electronics goods, in particular ICs, although the ASEAN economies have reduced their reliance on it as an intermediary over the last decade. Malaysia and the Philippines export about one-fifth and 10–15% of their IC products through Singapore respectively. Malaysia has established itself as the largest supplier of ICs to the US and Mexico, and has a share of 9% each in the IC imports of the EU and China. Malaysia's exports to Mexico are mainly channelled through the US, and a part of that trade comes through Singapore. Hence, Malaysia's significant role in these major markets has bolstered Singapore's re-exports. However, to meet the growing demand for ICs from China, Malaysia is forwarding more of its IC exports to Hong Kong instead while the Philippines has almost halved the proportion of ICs exported through Singapore over the last decade. As a result, Hong Kong now accounts for a sizeable 16% and 31% of their respective IC exports. Likewise, Singapore's IC re-exports to Malaysia and Thailand are now equivalent to roughly 15% of their respective imports, about 10% points lower than several years ago. In general, the regional countries are sourcing more directly from the Northeast Asian economies or via Hong Kong instead of importing from countries such as the EU and Japan through Singapore. Nevertheless, Singapore's IC re-exports to markets outside of China, including the US and EU, remain much larger than Hong Kong's, by about 1.3 times on average.

In addition, Singapore re-exports other electronics components and final products from China to the ASEAN countries. Singapore's re-exports account for the largest proportion of electronics imports into Indonesia (32%) and the lowest in Vietnam (5%). Vietnam instead imports mobile phone components, which accounts for 38% of its total electronics imports, mainly from China and South Korea.

For exports out of Southeast Asia, Singapore plays a much smaller role as a distribution centre, with notable volumes from only Malaysia. Malaysia ships to Singapore about 10% of the mobile phones, and 15% of PC parts. Among the HDD producers in the region, only Malaysia exports a small portion (of less than 10%) via Singapore.

In general, Singapore has adapted to the shifts in comparative advantage in electronics manufacturing worldwide by focusing on the high value-added activities in the global supply chain. Many of the world's top semiconductor companies have a presence in Singapore, which serves as their regional headquarters, research & development (R&D) centres or advanced wafer fabrication facilities. This has helped to entrench Singapore as a major global distribution hub for ICs and resulted in a rich domestic ecosystem of materials & equipment and EMS players. Indeed, Singapore accounts for as much as a fifth of the world's production of semiconductor equipment.

Services Linkages in Asia

The electronics trade flows have also facilitated the growth of services trade in the region. Embodied in every US dollar of Asia-11's electronics exports are 14 cents' worth of services imports, compared with 10 cents for manufacturing exports in general.³ Half of the services imports utilised by the electronics sector are in the trade-related categories of wholesale and retail trade (5 cents), and transport and storage (2 cents), in part reflecting the prevalence of cross-economy supply chains. Other business services and financial and insurance services account for another 3.0 and 1.6 cents, respectively.

Traditionally, Asia's manufacturing centres and some developed countries such as the US and Japan have dominated manufacturing-related services exports to the region. This trend reflects the trade flows, as well as the dominance of developed countries in the provision of services and their importance as a source of some high-tech intermediate inputs into Asia's manufacturing sector. Within Asia, Hong Kong and Singapore have also emerged as important transport hubs and financial centres. More recently, however, they are facing a challenge from China in trade-related services, and their market shares have declined by 0.6–0.7% point each over 2007–2015. Nevertheless, Singapore has continued to expand its market share in modern services, particularly other business services⁴ and information and communications services.

Alongside its transformation into the factory of the world, China has been rapidly gaining market share in the services arena. It is increasingly meeting more of its own demand for services, which were previously imported. Over the period 2007–2015, the domestic services value added (VA) content of China's electronics exports grew by 12.8% p.a., against growth of only 2.3% p.a. for foreign services VA content. As a result, China met two-thirds of its own electronics export sector's needs for services in 2015, up from 48% in 2007. These trends in part reflect the deepening of China's supply chains over the late 2000s, which led to greater domestic sourcing of inputs and thus a correspondingly higher contribution by supporting services sectors. China has also made considerable inroads into Asia-11's import market for electronics services. Over the past decade, its market share has more than doubled from 6% in 2007 to 12.4% in 2015 (**Chart 1**). Its gains were mainly at the expense of losses by

³ The Asia-11 economies are China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, Vietnam. Given the lack of detailed data on electronics-related services exports, the value added content of services embodied in electronics exports (in 2015) reported in the OECD TiVA database is used as a proxy.

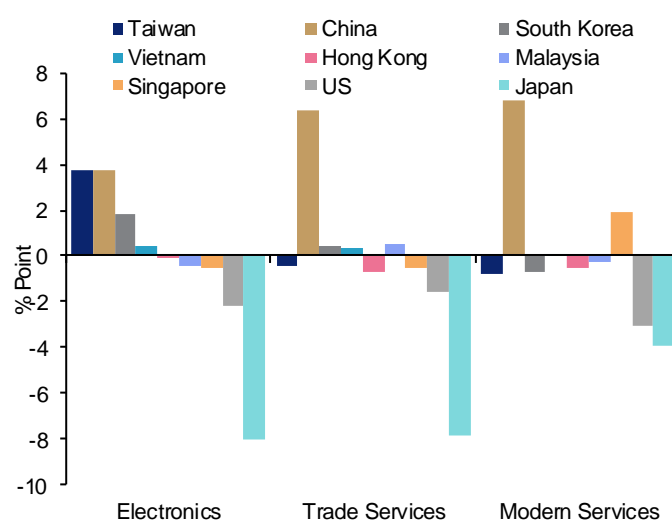
⁴ Other business services include legal and accounting services, activities of head offices, and research and experimental development.

developed countries such as Japan and the US, while the other Asia-11 economies largely recorded stable or slight declines in their market shares.

3 Post-tariff Shifts in Electronics Trade Flows

Since 2018, the US has imposed tariffs on Chinese products worth US\$370 billion, including final electronics goods such as mobile phones and laptops, as well as intermediate products such as semiconductors and computer parts. In response, China implemented retaliatory tariffs on about US\$110 billion of US products, including electronics goods. While there has been some de-escalation in trade tensions with both countries allowing some tariff exemptions, trade barriers are still significantly higher compared to 2017. Moreover, the threat of a re-escalation in trade tensions remains. As such, companies have begun to reconfigure their global electronics supply chains, taking into account both the impact of higher tariffs, as well as the risk of increased trade barriers. This section addresses the impact of higher US tariffs on global supply chains by tracing through corresponding changes in trade flows and market shares.⁵

Chart 1 Change in share of foreign VA in Asia-11's electronics-related exports by category (2007–2015)



Source: OECD TiVA Database and EPG, MAS estimates

In analysing the impact of higher US tariffs on Chinese goods, both direct and indirect effects are considered. First, the tariffs have a direct effect on the countries from which the US sources electronics products. As Chinese goods become more expensive, the US would likely either import more from other countries or increase domestic production. Second, as US purchases of Chinese goods fall, China will demand less inputs from its suppliers, thus indirectly leading to declines in their exports. Conversely, other countries that have gained market share will increase their imports of intermediate products from their suppliers.

To assess the shifts in trade flows in the post-tariff period, the changes in market share of US imports for 17 economies between 2017 and 2019 are computed. They cover the entire

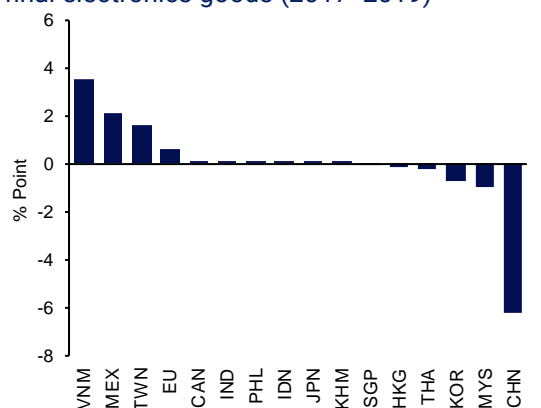
⁵ See Box A of the April 2019 issue of the *Macroeconomic Review* for an analysis of the impact of US-China tariffs and ongoing supply chain shifts on trade and production patterns in Asia based on a computable general equilibrium model.

gamut of the production and distribution networks in Asia—China, Japan, Korea, Taiwan and Hong Kong, as well as the ASEAN economies of Brunei, Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. In addition, the main trading partners of the US are considered—Canada, the EU, Mexico and India.⁶ The changes in market shares are calculated for final electronics goods as well as intermediate products, based on disaggregated trade data at the six-digit HS (Harmonised Commodity Description and Coding System) level.

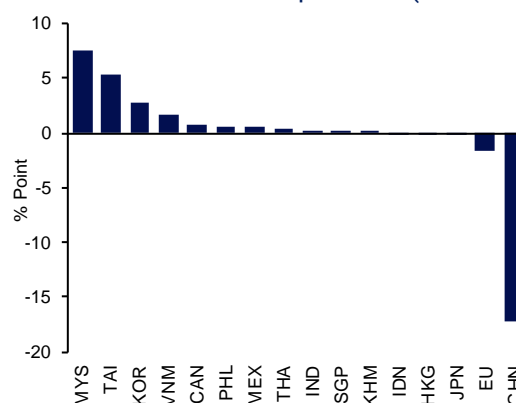
In the final electronics goods category, China was badly hit by US tariffs, suffering a sharp 6.3% point decline in its market share of US imports. Nevertheless, it remained the US' most important source of final electronics products and continued to supply more than half of its imports. Vietnam saw the largest gain in market share, of 3.6% points, followed by Mexico with 2.2% points, and Taiwan, with 1.7% points (**Chart 2**). Vietnam is a key beneficiary of production relocation from China, and has experienced a surge in FDI inflows into its manufacturing sector since mid-2018, with a notable increase in new projects originating from China. Mexico, which as noted above is the second largest supplier of final electronics products to the US after China, also gained significantly from trade diversion, given its proximity to the US and favourable tariff treatment under the US-Mexico-Canada Agreement (USMCA). Meanwhile, Taiwan has benefited from the accelerated reshoring of manufacturing lines from China.

Turning to the intermediate goods space, China witnessed a hefty 17.2%-point reduction in its share of the US import market, while Malaysia and Taiwan recorded the largest gains, of 7.4% points, and 5.3% points, respectively (**Chart 3**). The trade diversion to Taiwan again reflects the reshoring of production lines, as well as its competitive strengths in higher value-added upstream products. Meanwhile, Malaysia has traditionally been an important producer of intermediate electronics components and accessories, and has seen a surge in approvals for foreign investment in the electrical and electronics industry over the past two years. While Malaysia's technological capabilities still lag that of more advanced Asian economies such as Korea and Taiwan, its openness to FDI, relative availability of skilled labour and good transport networks stand out among the ASEAN economies. It is also noteworthy that Mexico did not gain significant market share in US imports of intermediate goods, in contrast to its advance in final goods. Although Mexico has had considerable success in attracting lower value-added production, it has fared less well in drawing investments in higher value-added upstream electronics manufacturing, in part reflecting its relatively unskilled workforce and weak supporting infrastructure.

⁶ Together, these 17 economies account for 99% of US imports of electronics. An important caveat is that not all of the post-2017 changes in market shares are necessarily due to the US trade tariffs.

Chart 2 Change in US import market shares for final electronics goods (2017–2019)

Source: ITC Trade Map, US Census Bureau and EPG, MAS estimates

Chart 3 Change in US import market shares for electronics intermediate products (2017–2019)

Source: ITC Trade Map, US Census Bureau and EPG, MAS estimates

Next, the indirect impact of higher tariffs on the intermediate input suppliers of final goods producers is examined. To do this, the changes in the sources of intermediate electronics imports in the top four exporters of final electronics goods to the US, namely China, Mexico, Vietnam and Taiwan, are examined.⁷ South Korea and Malaysia experienced the most significant improvements in market share in Mexico's imports of intermediate electronics, while Japan, the EU and China were the largest gainers in the Vietnam market. As for Taiwan, it sourced more intermediate imports from China, Malaysia and Vietnam, with these countries experiencing increases of 2.4–3.2% points in their market shares. Meanwhile, Vietnam, Taiwan and Malaysia also registered gains of 0.8–1.8% points in their respective shares of China's imports of intermediate electronics inputs, which, contrary to expectations, had increased in spite of a decline in exports of final electronics goods to the US. This suggests that the impact of China's efforts to enhance its domestic manufacturing capabilities more than offset the negative effects arising from US tariffs. Overall, the economies receiving the largest boost to their intermediate inputs trade are Vietnam, Taiwan and Malaysia.

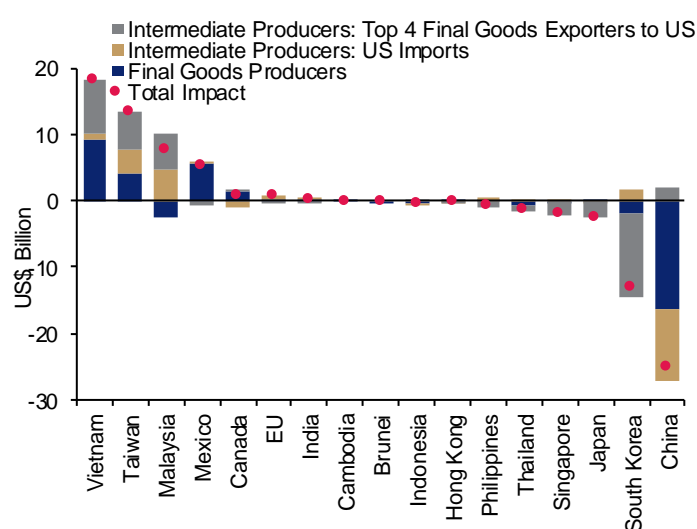
Chart 4 presents the total impact of the post-2017 market share changes, summarising the differences in each economy's 2019 electronics trade flows, using 2019 market shares *vis-à-vis* 2017 market shares. The direct impact of the tariffs is made up of the effects on US imports of final goods (blue bars) and of intermediate inputs (gold bars). The indirect impact comprises the changes in the economies from which the final goods exporters sourced their intermediate inputs (grey bars). When both the direct and indirect impacts are taken into account, Vietnam, Taiwan and Malaysia are the top beneficiaries. Meanwhile, Mexico comes in at fourth place due to its limited gain in market share of intermediate products, given that its electronics sector is geared towards downstream production. Vietnam showed increases in both final and intermediate electronics products, but Taiwan and Malaysia benefitted mainly from direct and indirect gains in intermediate electronics products.

In addition to importing from alternative sources, the US is also partially meeting its demand for electronics products by increasing domestic production, particularly for final goods. US production of final goods is estimated to have increased by an average 5.1% p.a.

⁷ As import data for Mexico and Vietnam is available only up to 2018, the analysis assumes that trade flows and market shares in 2019 are the same as in 2018.

in the past two years, compared with 3.9% p.a. in the prior five years. The country's output of intermediate electronics products grew by a robust 6.2% p.a. in 2018–2019, although this is still slower than the average of 8.6% p.a. registered in the preceding five years. Meanwhile, in China, there are signs that the share of domestically-produced intermediate products in overall electronics manufacturing has risen. While the production of final goods such as mobile phones and displays have contracted in the last two years due to US tariffs, the output of ICs have continued to expand at double-digit rates. This trend is likely to be a reflection of China's ongoing efforts to move up the supply chain, expedited by the trade tensions. Thus, instead of exporting final goods to the US, China can supply upstream intermediate inputs to the other producers of final goods.

Chart 4 Estimated change in electronics trade flows due to shifts in market shares between 2017 and 2019



Source: ITC Trade Map, US Census Bureau and EPG, MAS estimates

All in, it appears that the major nodes in Asia's electronics supply chain have remained broadly intact, although there has been some re-organisation of production away from China and towards manufacturers elsewhere in Asia, particularly Vietnam, Taiwan and Malaysia. Meanwhile, China appears to be adjusting to the tariffs by shifting production away from final goods and towards intermediate products. There is also tentative evidence of in-sourcing by the US and gains by Mexico, which suggest that the tariffs have catalysed the growth of the US-Mexico electronics production network.

4 Conclusion

The increased US-China trade barriers and technological restrictions in the last two years have raised the prospect that China and Asia's China-centric electronics production network will cede market share in the US market, with the US-Mexico supply chain gaining prominence instead over time. At the current juncture, the Asian supply chain is more mature, accounting for a dominant share of global electronics production, in both final and intermediate goods. The advanced development of Asia's production chain gives the region a competitive advantage over the US-Mexico one, and the range and sophistication of the firms involved would not be easily duplicated. In addition, upstream, mid-stream and downstream producers are all found in the region, clustered together to benefit from economies of agglomeration and scope.

Nevertheless, the US-Mexico supply chain could grow and become more sophisticated over time, even as Asia's production capabilities evolve. There are four key factors that underpin the competitiveness of supply chains: production costs, tariff barriers, human capital endowment and innovative edge. Beginning first with business costs, it remains the case that electronics goods are more cheaply produced in Asia than in US-Mexico. For every US dollar of output, unit business costs (i.e., excluding material costs) in the former amounted to only half of those in the latter—22 cents vs 48 cents.⁸ The difference is due largely to wages, which are 5 cents in Asia per US dollar of output, compared to 21 cents in US-Mexico, as a result of high labour costs in the US. The cost of supporting services in Asia is also considerably lower, reflecting the efficient provision of such services by Hong Kong and Singapore.

Second, intraregional tariffs on intermediate electronics products make it more costly for the Asian economies to source for inputs from each other. At present, the bilateral tariffs levied in the region are mostly around 4–5%. In comparison, the USMCA together with its predecessor NAFTA has effectively removed tariffs on the flow of electronics products between the US and Mexico in the North American supply chain. Third, the US is far ahead of Asia with regard to human capital endowment, with a much greater availability of skilled and high-quality workers. Correspondingly, its labour productivity level in the electronics sector is close to five times that of Asia. US universities continue to award the largest number of doctoral degrees in science and engineering (S&E) (39,900 in 2015) in the world. Nevertheless, China appears to be rapidly catching up, although from a low base. The number of S&E doctoral degrees awarded by universities in China rose from just 7,800 in 2000 to 34,400 in 2015. If Korea and Taiwan are included as well, the region's universities have awarded more S&E degrees than US since 2008, and collectively produced 42,900 S&E doctorates in 2015.

The US-Mexico electronics supply chain has the strong advantage conferred by the technological and innovative edge of the US. The US is the world leader in high-technology industries and remains highly invested in emerging technologies. Thus, it has the capability to increase the production of higher value-added intermediate goods, such as ICs for new applications like AI and 5G. Notwithstanding the advances made by China, the US continues to lead in the number of patent applications in the electronics sector, in both hardware and software.

Fourth, the US-Mexico supply chain in electronics production is supported by lower tariffs, higher quality workers and especially its dominant position in innovation. However, its cost base is significantly higher than Asia, which also holds the incumbent advantages of greater firm diversity and nimbler producer-supplier relationships. It is also unlikely that the region's labour cost advantage will be eroded over the short term. It is thus the case that both regions will remain as major producers and consumers of electronic products, even as important shifts in comparative advantage take place within Asia, giving rise to new opportunities for intra-industry specialised trade across the region.

⁸ The cost comparison is based on US Bureau of Economic Analysis data on the activities of US multinational enterprises.

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