Special Feature A The Evolving Pattern Of Production And Trade Networks In Asia¹

Introduction

Over the past two decades, Asia has emerged as one of the most dynamic production and trade centres in the global economy. During the 1980s, trade flows in the region were largely dominated by the exchange of goods between the US and Japan, alongside the export of manufactured products from the East Asian tigers of Korea, Taiwan, Singapore and Hong Kong. These patterns underwent dramatic shifts in the 1990s and 2000s, as first the larger ASEAN economies, and then China, emerged as manufacturing export powerhouses by opening themselves up to trade and foreign direct investment. More recently, several previously isolated economies-notably the "CLMV" countries (Cambodia, Laos, Myanmar and Vietnam)—have been following the same strategy to claim a share of the region's manufacturing activity. These cascading shifts by Asian countries towards more open trade and investment regimes have been instrumental in reshaping regional export patterns.

At the same time, these developments have taken place against the backdrop of rapid technological and engineering advances. Spearheaded by the rise of the internet, a plethora of new technologies significantly lowered the costs and time lags of cross-border communication. Often dubbed the information and communications technology (ICT) "revolution", this has spurred a reorganisation of manufacturing processes around the world, making available to many firms offshoring and international input-sourcing arrangements that were previously only feasible for the largest multinational corporations.²

Within the region, this has given rise to the notion "Factory Asia" (Baldwin, 2008). Asian of economies have become increasingly connected and intertwined in production processes that span national boundaries. The manufacture of modern, complex products in the region now routinely involves the sourcing of parts and components from suppliers located in multiple countries, each specialising in specific production tasks on the basis of their niche comparative advantage. Take as an illustration the case of Apple. It is wellknown that the final assembly of Apple's electronics products is performed by Hon Hai Precision Industry (better known as Foxconn) in several locations in China, but that is only part of the story. An examination of Apple's publicly disclosed list of suppliers reveals that it has an extensive network of links in Asia, with parts sourced from Japan, South Korea, Taiwan, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

This Special Feature sets out to document how the configuration of production and trade activity in Asia has altered between 1995 and 2014, a period of striking economic transformation in the region. As such, it represents one of the first systematic attempts to compute the "upstreamness" of the regional economies' export profiles by applying the methodology

¹ This feature was done in collaboration with Associate Professor Davin Chor from the Department of Economics, National University of Singapore.

See Baldwin (2011) and Antràs (2015) for an overview of the technological forces and policy changes behind the rise of global production arrangements. See also Hummels, Ishii and Yi (2001), Johnson and Noguera (2012), and Koopman *et al.* (2014) for contributions that document the rise in cross-border trade associated with vertical production linkages.

in Antràs *et al.* (2012). The measure of upstreamness proposed by these authors serves as a descriptive tool to characterise the relative position that each Asian economy occupies in global production processes, and how this has shifted over the last two decades.

The empirical exercise confirms the pivotal role that China has played in re-defining regional production and trade patterns. Economies in the rest of the region such as Korea, Taiwan and Singapore are now positioned as upstream suppliers of materials, parts and components, which are used extensively as inputs into China's downstream manufacturing assembly activity. To further understand these movements in countries' production line positions, the industry export mix of individual economies is examined to patterns discern how specialisation have responded to the rise of China over the past two decades. In light of these developments, the Feature concludes with a discussion of the evolving comparative advantage of Asian economies. It identifies the opportunities and challenges that they currently confront, and the structural changes that are taking place as China moves into new segments of industrial activity.

The Concept Of "Upstreamness"

This section briefly summarises the methodology developed in Antràs *et al.* (2012) to describe the average position that countries occupy within global value chains. These researchers propose a measure of the upstreamness of industries, which can be used to broadly characterise whether an industry is primarily a producer of an upstream raw input, a midstream intermediate input, or a downstream finished good.

The basic data required for constructing this industry upstreamness measure is from the Input-Output tables. The detailed information in these tables allows the calculation of how much industry i's output enters exactly one stage prior to final use, two stages prior to final use, and so on. The upstreamness, U_i , of industry i is then computed as the average number of stages prior to final use at which the industry enters an economy's value chain.³ By construction, U_i takes on values larger than or equal to one. When $U_i = 1$ (this being the most downstream value possible), the industry is just one stage removed from final demand, with the entirety of its output channelled towards consumption or investment uses. In comparison, a larger value of U_i means that industry *i* tends to enter production processes as an upstream input that is a greater number of stages removed from final demand.

In Table 1, the U_i values for an illustrative subset of US manufacturing industries that are of particular relevance to Asia are reported. These values are taken from Antràs *et al.* (2012), who calculated the U_i 's by using the 2002 US Input-Output Tables.

3

$$U_{i} = 1 \cdot \frac{F_{i}}{Y_{i}} + 2 \cdot \frac{\sum_{j=1}^{N} d_{ij}F_{j}}{Y_{i}} + 3 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} d_{ik}d_{kj}F_{j}}{Y_{i}} + 4 \cdot \frac{\sum_{j=1}^{N} \sum_{k=1}^{N} \sum_{l=1}^{N} d_{il}d_{lk}d_{kl}F_{j}}{Y_{i}} + \dots$$

Here, N is the number of industries, Y_i is the gross output of industry i, F_i is the value of that output which is purchased for final uses, and d_{ij} are the purchases made by industry j of inputs from industry i (per dollar of industry j's output). Fally (2012) provides an alternative recursive formulation that yields an equivalent upstreamness measure.

A more detailed exposition of this upstreamness measure can be found in a Special Feature published in the April 2014 issue of the *Review*. Formally,

Industry (IO2002)	U _i
Automobile	1.000
Footwear	1.007
Electronic Computer	1.043
Men's and Boys' Apparel	1.075
Pharmaceutical Preparation	1.309
Computer Storage Device	1.784
Motor Vehicle Parts	2.295
Petroleum Refineries	2.396
Broadwoven Fabric Mills	2.465
Semiconductor and Related Device	2.909
Iron and Steel Mills and Ferroalloy	3.358
Plastics Material and Resin	3.571
Petrochemicals	4.651

Table 1 Upstreamness Values for Selected US Manufacturing Industries

Source: Antràs et al. (2012)

The U_i measure captures the broad differences between industries that produce finished goods such as automobiles and computers ("downstream"), those that produce intermediate materials and components, such as motor vehicle parts ("midstream"), and those engaged in the processing of raw materials, such as iron and steel mills ("upstream").⁴

To shed light on the relative position of countries in global supply chains, the above measure of industry upstreamness is combined with international trade data. ⁵ The "export upstreamness" of a country c in year t, $U_{c,t}$, is computed as:

$$U_{c,t} = \sum_{i=1}^{N} \frac{X_{ci,t}}{X_{c,t}} U_{i}$$

where $X_{ci,t}$ is the value of country c's exports in industry *i*, while $X_{c,t}$ is the value of country *c*'s total exports (summed across all industries) in year t. In words, $U_{c,t}$ is a weighted average over the upstreamness of the industries (the U_i 's), where the weights are equal to the share of each industry in the total exports of country c in year t. The export profile of a country with a high $U_{c,t}$ would therefore be skewed towards more upstream industries, while a country with a low U_{ct} would be geared more towards exporting downstream finished goods. This export upstreamness measure will be used to document how cross-border production and trade networks have evolved in the Asian region over the last two decades.

The industry upstreamness measures calculated by Antràs *et al.* (2012) further incorporate open economy and net inventories corrections to account respectively for output flows into and out of the country, as well as into and out of inventories. The 2002 US Input-Output Tables adopt a detailed industry classification, with 426 industries in total, of which 279 are in manufacturing. The most downstream manufacturing industry is automobiles, while the most upstream is petrochemicals.

⁵ The trade data used for this exercise is from the CEPII BACI dataset covering the period 1995–2014, and is based on the 1992 version of the Harmonized System codes (HS1992). These are converted into the industry classification system of the 2002 US Input-Output Tables (IO2002) using a concordance provided by the US Bureau of Economic Analysis.

The Evolution Of Export Upstreamness Across Asia

Before examining the shifts in the export upstreamness of individual Asian economies, an overview of how the production line position of the region as a whole has evolved in recent times will be provided. Chart 1 plots the overall export upstreamness of a set of key economies in East and Southeast Asia that are the focus of this study.⁶

As can be seen from the figure, the export upstreamness of Asian economies as a whole lies just above 2, so that the "average" product exported by the region is an intermediate input slightly more than one stage removed from final use. Notably, the region's export upstreamness has been rising steadily since the early 2000s, with only a brief interruption to this trend during the GFC. The implication is that trade in upstream inputs has indeed became more prevalent, and crossborder supply chains more fragmented within Asia, particularly over the last 15 years.⁷

The upward trend in export upstreamness is even more pronounced when China and Hong Kong are excluded from consideration, the latter due to its role as an entrepôt for China. The export upstreamness of the region excluding China and Hong Kong rose from about 2.2 in 2000 to almost 2.4 at its peak in 2011. In contrast, the upstreamness of the exports of China and Hong Kong remained a notch lower, at around 1.8. In other words, the rest of the region became increasingly specialised in the production of upstream parts and components, while China's exports were more focused on downstream assembly activity.



Chart 1 Asia's Export Upstreamness

China's Centrality In Asia's Networks

In view of the broad trends in the region's export upstreamness, it is instructive to trace the evolution of bilateral trading relationships among individual economies, with the objective of describing the concomitant changes in the relative position of each country along crossborder supply chains. Charts 2 to 4 depict the changing networks of trade flows between the Asian economies, and in relation to the US, UK, Eurozone, Australia, as well as the rest of the world (ROW).

In these charts, the arrows indicate the direction of the net trade balance between each pair of economies, while the width of each arrow is proportional to the magnitude of this balance.

⁶ The economies included are China, Korea, Taiwan, Hong Kong, Singapore, Indonesia, Malaysia, the Philippines, Thailand, Cambodia, Myanmar, Laos and Vietnam.

⁷ This finding echoes Antràs (2015), who reports a similar increase in export upstreamness for the world as a whole.

The arrows are colour-coded to reflect the upstreamness of the export flows that move in the same direction as the net trade balance between each pair of nodes.

For simplicity, export upstreamness values lying between 1 and 2 are labelled as "downstream" (green), those between 2 and 2.5 as "midstream" (yellow), and those above 2.5 as "upstream" (red).



Note: The arrows reflect the direction of net trade, while their width corresponds to the magnitude of the trade balance. The colours indicate the upstreamness of export flows in the direction of the arrows.

Starting with the trade landscape in 1995 (Chart 2), the strength of linkages involving the advanced economies was especially prominent, with the US as a key demand driver, and Japan the largest source of the US' imports. Notably, Japan featured as a key node in the Asia-Pacific region, importing upstream inputs from Australia and the ROW, and thereafter exporting downstream goods to the US, UK and Eurozone. At the same time, Japan was a key supplier of midstream products to the NEA economies (Korea, Taiwan, Hong Kong) and Singapore. Separately, China was already an important exporter of downstream goods to the US, and to a lesser extent, the Eurozone and Japan, although the magnitude of its exports was more modest as compared to Japan. However, China's trading ties with the other economies in Asia were relatively sparse in 1995, indicating that its integration into the region's production and trade networks had vet to commence.

Following the turn of the millennium, the pattern of Asia's networks saw dramatic shifts. Catalysed by the ICT revolution, the greater scope for exploiting diverse sources of comparative advantage and economies of scale further drove the division of production stages across geographic boundaries (Baldwin, 2011). Within Asia itself, several key economies took steps to liberalise trade and foreign direct investment, prompting a wave of offshoring activity. This confluence of factors sparked several major developments in regional trade patterns that became evident by the mid-2000s.

First, a China-centric trade network had emerged by 2005. (Chart 3) Following China's accession into the WTO in 2001, the centre of gravity of Asian trade shifted towards the country. By 2005, China had established a pattern of activity in which it sourced upstream intermediate inputs from Korea and Taiwan, and subsequently transformed these into downstream finished goods to be exported mainly to the US and European markets. This marked a notable departure from the situation in 1995, when the fortunes of the NEA exporters and Singapore were tied to their direct trade links with the US and Europe. The rise in China's central position in world trade continued unabated in the last decade, when its importance as a conduit between Korea and Taiwan on the one hand, and the consumer markets of the US, Europe, and the ROW on the other hand, became even more entrenched.⁸ (Chart 4)

Second, Japan's waning role in the regional trade network had become apparent by the mid-2000s. (Chart 3) By 2014, Japan's importance as a key node had diminished further, and it became an importer of intermediate inputs from the ROW instead. (Chart 4) The magnitude of its net exports of finished goods to the US and Europe, as well as its net exports of midstream products to the NEA economies, had also declined significantly.

Third, the gradual integration of the CLMV countries into Asia's trade networks suggests that these economies could emerge as secondary nodes in the future. For example, Vietnam's role in 2005 in the region's production networks was marginal (Chart 3), with its trade activity largely confined to primary products. However, the country emerged as a mini-assembly hub around 2010, sourcing upstream and midstream inputs from China and the NEA economies, and thereafter exporting finished goods to the US and Eurozone. These trade flows have been increasingly concentrated in the electronics space, as Vietnam gained a foothold particularly in the mobile phone-related segment.

Shifts In Asia's Export Composition

Next, a more disaggregated view of what lies behind the shifts in the supply chain position of individual countries will be provided. Chart 5 plots the upstreamness measures for each economy's manufacturing exports over the past two decades.⁹

⁸ Accordingly, China's share of global exports tripled from less than 4% before 2000, to over 12% in 2014.

⁹ To compute the upstreamness of manufacturing exports of each economy, the same formula as for overall export upstreamness is applied, but only manufacturing industries are included when computing the weighted average. The weights are the corresponding shares of each industry in the economy's total manufacturing exports. Hong Kong is excluded as its manufacturing sector accounted for less than 3% of GDP since the 2000s.

Chart 6 complements these results by showing the accompanying changes that have taken place in the industry composition of each country's manufacturing exports to China.

Taken together, the charts shed light on the industries that have come to define each economy's supply chain position in relation to China.



Upstreamness of Asia's Manufacturing Exports, 1995–2014

Chart 5

Chart 6

Composition of Asia's Exports to China (% Share of Manufacturing Exports) (a) NEA-2 and Singapore (b) ASEAN-4





(c) CLMV



Monetary Authority of Singapore

Looking first at the NEA-2 and Singapore, these economies have experienced distinct increases in the upstreamness of their manufacturing exports, especially in Taiwan and Singapore. This can be attributed to the relatively faster expansion of their exports from upstream industries within the electronics cluster, and semiconductor inputs $(U_i = 2.909)$ in particular. Between 1995 and 2014, the electronics share in manufacturing exports to China rose from 8.5% to 32.2% in Korea, from 17.5% to 36.8% in Singapore, and from 9.1% to 63.7% in Taiwan. In the case of Singapore, electronics exports to China moderated between 2005 and 2014, but this was compensated by an increase in exports of refined petroleum $(U_i = 2.396)$ and petrochemicals $(U_i = 4.651)$.¹⁰

The ASEAN-4 economies also registered steady increases in their manufacturing export upstreamness beginning from the mid-1990s. Up until 2005, this was again largely driven by the electronics cluster. However, the share of electronics in the export baskets of Malaysia, Thailand and Indonesia all experienced a marked step-down thereafter, coinciding with the consolidation of IT production in China, alongside the rise of Vietnam as an electronics hub. In the latter half of the 2000s, the steady climb in these countries' export upstreamness was instead fuelled by exports of refined petroleum and chemical products. The situation was different in the Philippines, with the electronics share in its exports of manufactured products to the world rising from 32.2% in 1995 to 56.0% in 2014. The corresponding figures are even more striking as a share of manufacturing exports to China: the electronics share rose from 3.4% in 1995 to 78.3% in 2014 as the Philippines emerged as a key supplier of computer storage devices, computer peripherals, and semiconductors to China's booming computer assembly industry.¹¹

Meanwhile, the picture among the CLMV countries was more mixed. Vietnam saw an increase in its manufacturing export upstreamness over 1995–2014, driven by an expansion in exports of semiconductors and telephone apparatus. In comparison, Cambodia's and Myanmar's manufacturing exports grew distinctly more downstream by 2014. In the case of Cambodia, this reflected the relocation of downstream textiles/apparel manufacturing from China.

Lastly, China's export profile always remained more downstream when compared to the ASEAN-4, NEA-2 and Singapore. This suggests that China has consistently maintained its role as an assembly hub that occupies a relatively downstream position in global manufacturing value chains.

Evolving Patterns Of Comparative Advantage In Asia

Even as China emerged as a central node around which Asian trade networks are configured, its role in manufacturing supply chains has continued to evolve. <u>First</u>, there is growing evidence that China is moving beyond its traditional role as a mere assembler of imported inputs. Based on firm-level data, a recent study by Kee and Tang (2016) indicates that manufacturers in China are now performing more supply chain activity within the country. In particular, it appears to have enhanced its domestic production capabilities, with processing exporters progressively reducing their use of imported inputs and replacing these with domestically-produced materials. Quite apart from cost considerations, this substitution strategy was spurred by China's trade and FDI

¹⁰ Total exports inclusive of re-exports are used in the computations. However, the qualitative patterns are similar when domestic exports are considered (i.e., total exports excluding re-exports) instead.

¹¹ At first glance, the rise in the Philippines' manufacturing exports in electronics to China may seem at odds with the fact that its manufacturing export upstreamness dipped between 2005 and 2014. Although the upstreamness of the Philippines' exports to China rose during this period, this was offset by an increase in its exports of downstream finished goods (such as audio and video equipment) to the US and Eurozone.

liberalisation policies since the early 2000s. Specifically, the rise in FDI and falling input tariffs lowered the prices of domestic materials, which raised the domestic content in exports from 65% to 70% over the 2000–07 period.

<u>Second</u>, given its rapidly ageing workforce, labour cost increases in China have started to outpace productivity gains. Over the past ten years, wages in the manufacturing sector climbed by an average of 13% per annum, while productivity rose by only about 7%. This has prompted a shift away from labour-intensive production, towards industries that are more capital-intensive or require more skilled labour inputs.

Taken together, these developments will have significant effects on the composition of China's production and exports, some of which are already becoming evident. Reflecting the upgrading of its industrial base, China's exports have indeed become more skill- and capitalintensive over time. (Chart 7) Likewise, the R&D intensity of China's exports has also gradually trended up. This ongoing transformation of China's manufacturing sector raises both challenges and opportunities for the rest of Asia. To thrive in this shifting competitive landscape, regional countries will need to nimbly adjust their growth strategies to leverage off their comparative advantage, and to enhance or grow new capabilities.

The more advanced manufacturing economies of Korea, Singapore and Taiwan will face growing competition from China as it progressively enters into their traditional domain of upstream products, particularly in electronics, chemicals, and petroleum refining. Although China's electronics exports are still relatively downstream, being largely concentrated in goods such as computers and wireless equipment, it is engaging in the production of more upstream components.

Indeed, China's share of global semiconductor exports has risen from being negligible in 1995 to 8.7% in 2014. Similarly, China's global market share of petroleum refining and chemical products has climbed from 1.6% to 5.5% over the same period. As Chart 7 shows, China's export profile is also exhibiting significant catch-up with the NEA economies and Singapore, especially in its skill and R&D intensity. Moving forward, this implies that the NEA economies need to carve out niche areas where they can develop and retain a technological advantage over China.

Meanwhile, even as the ASEAN-4 economies seek to upgrade their capabilities and move into higher value-added production, the competition they face from China in this area will remain strong. In the semiconductor industry, for instance, the ASEAN-4's world market share rose from 6.3% in 1995 to a peak of 18.6% in 2003, but then declined to 13.5% in 2014 as China expanded its output. At the same time, the ASEAN-4 countries also face competitive pressures at the downstream end of the manufacturing space from the lower-cost CLMV countries that have emerged as regional players. Along with these developments, the skill and R&D intensity of ASEAN-4 exports appears to have fallen (Chart 7), pointing to the urgent need to increase investments in physical and human capital. As a complementary strategy, the ASEAN-4 countries can leverage on their resource base, but look beyond exporting upstream mining and agricultural products that are only lightly processed at present. For example, Malaysia has seen a trend towards higher investments in downstream petrochemical production capacity, thus diversifying away from petroleum refining.

The CLMV countries are potentially the chief beneficiaries of China's shift away from labourintensive downstream production. These countries are increasingly plugged into global production chains as a growing number of manufacturers in industries such as textiles, apparel and footwear chose to locate their operations in these lower-cost centres rather than in China. For textiles/apparel, although China continues to command an outsized global market

share of 36% in 2014, Cambodia, Vietnam, and more recently, Myanmar, have seen exports surge strongly, albeit from a low base. Consequently, Cambodia's and Vietnam's market shares of world exports in textiles/apparel have risen from nearzero in 1995 to 1.2% and 3.7%, respectively. To continue attracting downstream manufacturing activity in labour-intensive industries, these economies need to foster an investment-friendly climate and strong domestic institutions.



Chart 7 Factor Intensity of Asia's Manufacturing Exports, 1995–2014) Skill Intensity (b) Capital Intensit

Note: The export factor intensity measures are computed in a manner analogous to the export upstreamness variables, by taking a weighted average of the respective industry factor intensities, and using the export share of each industry in manufacturing exports as weights. The industry measures are calculated as follows, and are each standardised to a mean of zero and a standard deviation of one:

Skill Intensity: Log(No. of Non-production Workers/Total Employment), data from the NBER-CES dataset.

Capital Intensity: Log(Real Capital Stock/Total Employment), data from the NBER-CES dataset.

R&D Intensity: Log(0.001 + (R&D Expenditure/Sales)), data from Orbis, as computed by Nunn and Trefler (2013).

Concluding Comments

Over the longer term, the evolution of production and trade networks in the Asia-Pacific region will likely be shaped by three underlying forces. First, the absorption of supply chain activity back into China could adversely affect Factory Asia, in particular the NEA-2 economies and Singapore, which have grown on the back of strong demand from China for intermediate inputs. These trends are posing significant policy issues as to how these economies can sustain their growth for the long term.

Second, the benefits that Asia has reaped from the demographic dividend are beginning to wane,

given the ageing demographic profiles of China and the NEA economies. While this presents a further challenge to these countries, it also potentially opens up opportunities for the CLMV countries to gain from becoming new centres of labour-intensive manufacturing activity.

Third, a rising middle class in China and elsewhere in emerging Asia could provide a significant boost to trade in a wide variety of consumer goods. This would present manufacturers with opportunities to re-position themselves along a vast array of existing and new supply chains that produce consumer goods targeted at the Asian market.

References

Antràs, P, Chor, D, Fally, T and Hillberry, R (2012), "Measuring the Upstreamness of Production and Trade Flows", *American Economic Review Papers and Proceedings*, Vol. 102(3), pp. 412–416.

Antràs, P (2015), *Global Production: Firms, Contracts, and Trade Structure*, Princeton University Press.

Baldwin, R E (2008), "Managing the Noodle Bowl: The Fragility of East Asian Regionalism", *The Singapore Economic Review*, Vol. 53(3), pp. 449–478.

Baldwin, R E (2011), "Trade and Industrialization after Globalization's 2nd Unbundling: How Building and Joining a Supply Chain are Different and Why it Matters", *NBER Working Paper* No. 17716.

Fally, T (2012), "Production Staging: Measurement and Facts", mimeo.

Hummels, D, Ishii, J and Yi, K-M (2001), "The Nature and Growth of Vertical Specialization in World Trade", *Journal of International Economics*, Vol. 54(1), pp. 75–96.

Johnson, R C and Noguera, G (2012), "Accounting for Intermediates: Production Sharing and Trade in Value Added", *Journal of International Economics* Vol. 86(2), pp. 224–236.

Kee, H L and Tang, H (2016), "Domestic Value Added in Exports: Theory and Firm Evidence from China", *American Economic Review*, Vol. 106(6), pp. 1402–1436.

Koopman, R, Wang Z and Wei, S-J (2014), "Tracing Value-Added and Double Counting in Gross Exports", *American Economic Review*, Vol. 104(2), pp. 459–494.

Monetary Authority of Singapore (2014), "Where are Countries Positioned Along Global Production Lines?" *Macroeconomic Review*, Vol. XIII(2), pp. 94–99.

Nunn, N and Trefler, D (2013), "Incomplete Contracts and the Boundaries of the Multinational Firm", *Journal of Economic Behavior & Organization*, Vol. 94(1), pp. 330–344.