Incomplete draft: Lots of comments welcome

Supply-chain trade: A portrait of global patterns and several testable hypotheses

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ABSTRACT

The trade associated with international production networks – supply-chain trade for short –is associated with some of the most momentous global economic changes in the last 100 years. has transformative implications for the world economy. This paper presents a portrait of the global pattern of supply-chain trade and how it has evolved since 1995. The paper draws on a variety of data sources but most heavily on the recent World Input-Output Database. China's pattern receives special attention.

JEL codes:

Keywords: Supply-chain trade, vertical specialisation trade, fragmentation, second unbundling, task trade.

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1. INTRODUCTION

The trade associated with international production networks – supply-chain trade for short – is transformative according to policymakers (Lamy 2010). Among economists, however, it is typically viewed as normal trade that is concentrated in parts and components (Grossman and Rossi-Hansberg 2008). Here we argue that the facts are on the side of the policymakers. Flourishing supply-chain trade has had transformative effects on the global economic relations. We start with its timing.
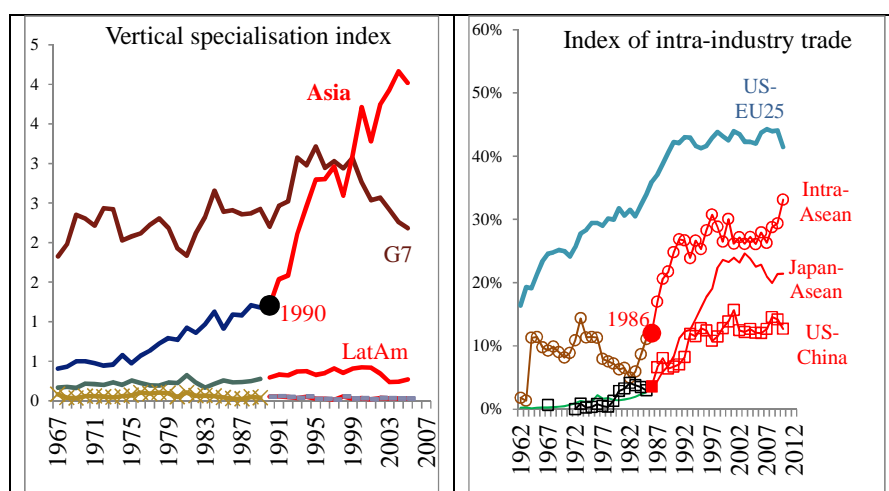

Figure 1: Indirect measures of supply-chain trade from 1960s.

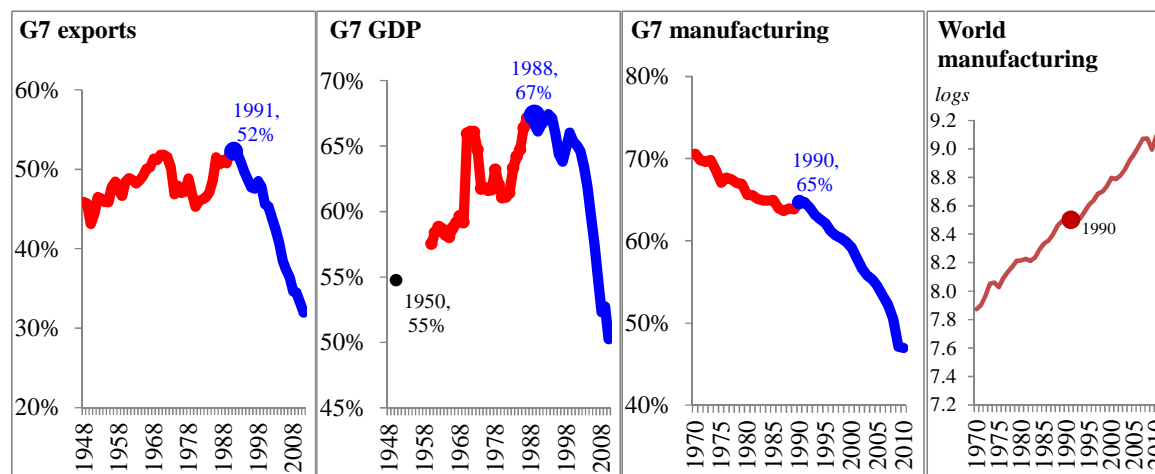Source: left: Amador and Cabral (2006); right: Brülhart (2009).

Figure 2: G7 share of world income, trade and manufacturing.

Sources: WTO, World Bank and Maddison, UNstats.

Supply-chain trade has been important among rich nations for decades (e.g. US-Canada and intra-EU). From the mid1980s, it gained importance between high-tech and low-wage nations during globalisation's '2nd unbundling' which, roughly speaking, boomed from the mid1980s.[1] Figure 1 illustrates the timing with two proxies for supply-chain trade – a 'vertical specialisation' index and partner-wise intra-industry trade indices. These changes

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[1] See Baldwin (2006a); during globalisation's 1st unbundling (1850 to 1985), international competition was at the level of sectors; in the 2nd unbundling, it operated at the level of stages of production with many stages being offshored to lower cost locations.

have been widely noted. The mid1980s structural break has been shown by many (Dallas Fed 2002, Feenstra and Hanson 1996, Ando and Kimura 2005, and Fukao, Ishito, and Ito 2003) and the trade changes by many others (Hummels, Ishii, and Yi 2001, Yi 2003, Bems, Johnson, and Yi 2010, Koopman, Powers, Wang, and Wei 2011, and Johnson and Noguera 2012a,b).

The momentous changes are even easier to spot. Up to the end of the 1980s, globalisation was associated with rising G7 shares of world trade and income, and a gentle slide in its manufacturing share. Afterwards, globalisation worked very differently (Figure 2).

- When North-South production unbundling took off, G7 world shares of income and exports plummeted and its manufacturing decline accelerated -- despite steady manufacturing growth globally.

At about the same time, the political economy of trade liberalisation turned on its head.

- Developing nations that had eschewed trade liberalisation for decades, suddenly embraced openness that facilitated international production sharing.

They slashed tariffs unilaterally (especially on intermediates), signing Bilateral Investment Treaties (BITs, which are mostly unilateral concessions to rich-nation firms seeking to invest), signing Regional Trade Agreements (RTAs) with 'deep' provisions that are pro-supply-chain (e.g. assurances for intellectual property, capital movements, inward investments, competition policy, business visas, etc.); see Figure 3.

At about the same time, developing nations' share of global manufacturing output and exports soared – at least for those near enough to be in US, Japanese or German supply chains.
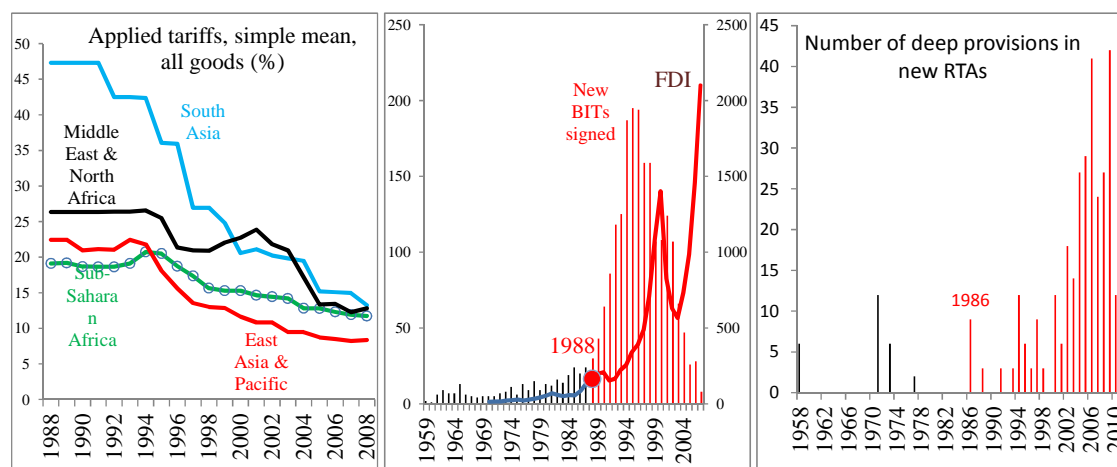
Figure 3: Take-off in BITs, FDI, unilateralism, and deep RTAs.

Sources: Tariffs from World databank, deep RTA provisions from WTO, BITs from ICSID.

The geography of the winners and losers is stunning (Figure 4). There are over 200 customs areas in the trade data, but most have tiny populations – smaller than the city of Philadelphia. If we limit attention to non-tiny nations (populations over 5 million) and to nations that rely on manufactured exports (manufactures account for more than 50% of their exports in 2007-08) then a pattern emerges.

- Some of these nations' manufacturing export shares rose from the 1980s while fell; the share-winners and share-losers, however, are tightly clustered.

- There seems to be one group of winners and losers around Germany, one around the US, and one around Japan.

India may also be at the centre of a cluster of winners involving Bangladesh, Pakistan, and Sri Lanka.

Figure 4: The tight geographical clustering of manufactures export swings.

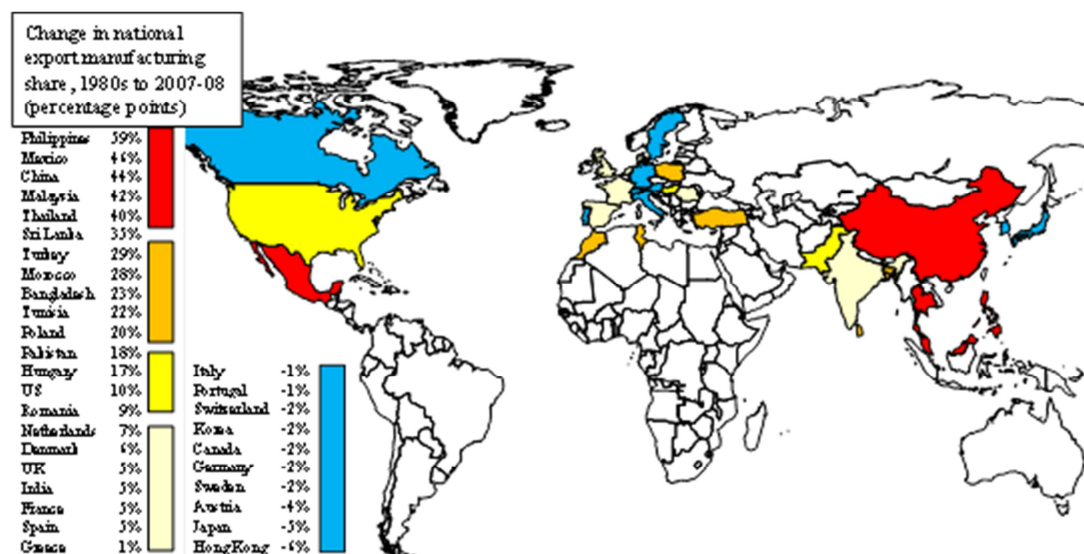Note: Data for all nations with 1) population over 5 million, 2) manufacturing export share over 50% in 2007-08, 3) at least 90% data coverage 1985 to 2008. Source: Author's calculations on World Bank data.

1.1. What changed?

All these changes are in line with the likely impact of what has been called 'globalisation's 2nd unbundling', namely North-South production sharing. When Toyota makes car parts in Thailand, they do not rely on local know-how; they bring Toyota technology and any other bits of know-how needed since the Thai-made parts have to fit seamlessly into the company's production network. As a result, the 2nd unbundling is not just more goods crossing borders; it also heightened the international mobility of managerial and manufacturing know-how.

In a handful of nations located near the US, Germany or Japan, this removed many bottlenecks that had previously stymied their industrialisation. These nations could industrialise by joining supply chains rather than building their own from scratch (Baldwin 2012). The resulting industrialisation occurred at a pace hereto unheard of for a handful of 'emerging markets'. This booming industrialisation uplifted exports and terms-of-trade for commodity-exporters, thus creating a new class of commodity-reliant emerging markets. As Figure 2 showed, this revolutionised the global pattern of trade, income and manufacturing.

Given the transformative nature of these developments and their prima facie connection to production sharing, the global pattern of supply-chain trade is surprisingly ill-understood by most economists and policymakers. This is where our paper fits in. It should be thought of as a contribution towards better understanding the options facing policymakers and more precisely formulating empirically testable hypotheses. We draw on a variety of data sources but most heavily on linked input-output tables of the types discussed in the seminal work by Hummels Ishii and Yi (2001) which motivated the recent literature on 'value added' trade notably Johnson and Noguera (2012a,b), Koopman et al. (2011), Timmer et al (2011), and Daudin, Rifflart and Schweisguth (2011). But first we lay out the basic concepts and conditioning facts.

NEEDS PLAN OF PAPER

2. BASIC CONCEPTS AND CONDITIONING FACTS

The importance of trade in intermediates has long been recognized in empirical work (e.g. and Grubel and Lloyd 1975) and theoretical work (Batra and Casas 1973, Woodland 1977). Its importance has been 're-discovered' every decade since – each time providing a fresh set of terminology: in the 1980s (Ethier 1982, Dixit and Grossman 1982, Sanyal and Jones 1982, Helpman 1984, Deardorff 1989a, b); in the 1990s (Jones and Kierzkowski 1990, Francois 1990, Yi 1998, Venables 1999); in the 2000s (Hummels, Ishii and Yi, 2001, Kohler 2004, Markusen 2006, Grossman and Rossi-Hansberg 2008, Antràs et al. 2006), and in the 2010s (Johnson and Noguera 2012, Koopmans, Wei and Zhang 2012).

To fix ideas, this section introduces basic concepts and key conditioning facts.

2.1. Supply-chain trade's 3 basic concepts: I2P, I2E, and factor-content trade

Traditional trade statistics measure the value of the goods as they cross the border. The importing nation's customs authority gathers information on the type of good and where it came from. What is missing is information on usage. Are they final goods or intermediate goods? The three basic supply-chain trade concepts are grounded on this single distinction: final versus intermediate usage (See Box 2).

While the terms for supply-chain trade are numerous, the essential concepts are universal.

- The broadest view of supply-chain trade is "importing to produce" – which we shorten to I2P; this encompasses all imported intermediate inputs including raw materials and services.

- A particularly policy-relevant subset of I2P comprises the intermediates related to exporting, i.e. "importing to export", or I2E for short.

Crossing intermediates with imports and exports, we get another key distinction – the sales and sourcing patterns of intermediates. I2P on the sourcing side reflects a nation's import of intermediates; on the sales side, it reflects exports of intermediates. For many nations, the sales and source patterns differ in important ways.[2]

I2E is a recursive concept; a nation's imported intermediates from a given partner usually contain intermediates from third nations and even from the nation itself. Some supply-chain trade measures focus on aspects of the recursive-ness (e.g. reexporting); more on this below.

- When the recursion is fully worked out – so that the origin of all primary factor inputs in exports is identified – we have factor-content trade, which was recently re-dubbed as "value-added trade" (Daudin, Rifflart and Schweisguth 2011, Koopman et al. 2011, Johnson and Noguera 2012).

I2P and I2E are useful for understanding how trade is related to the national distribution of gross production. Factor-content trade is useful for understanding trade's link with the national distribution of net production, i.e. value added. Or to put it differently, if you care about links between trade and local manufacturing, I2P and I2E are critical. If you care about links between trade and local manufacturing jobs, factor-content trade is critical. See Box 1 (at the end of section) on 'vertical specialisation' trade.

2.1.1. Supply-chain trade and the final versus intermediates distinction

Before elaborating on the implications of the final-versus-intermediate distinction, we show

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[2] Russia sells natural resources to international supply chains while sourcing manufactured inputs from them.

that it is important in the data. We rely on a recent joint effort by the OECD, WTO, World Bank and the European Commission that produced the so-called the World Input-Output Database (WIOD); see Timmer et al (2011).[3] WIOD shows where each sector in each nation obtains its inputs and sells its output – being careful to distinguish purchases of the goods for intermediate usage and final usage.

The top panel of Figure 5 shows that on average half of all goods and services produced in the world are sold for final usage (public and private consumption and investment). The final-sale shares, however, varies from 30% (Luxembourg) to almost 70% (Cyprus). Interestingly, China is at the low end of the scale, suggesting China is more heavily focused on intermediates than the global average. Indeed, as we shall see below, China has become to industrial inputs what Saudi Arabia is to oil – the linchpin global player.
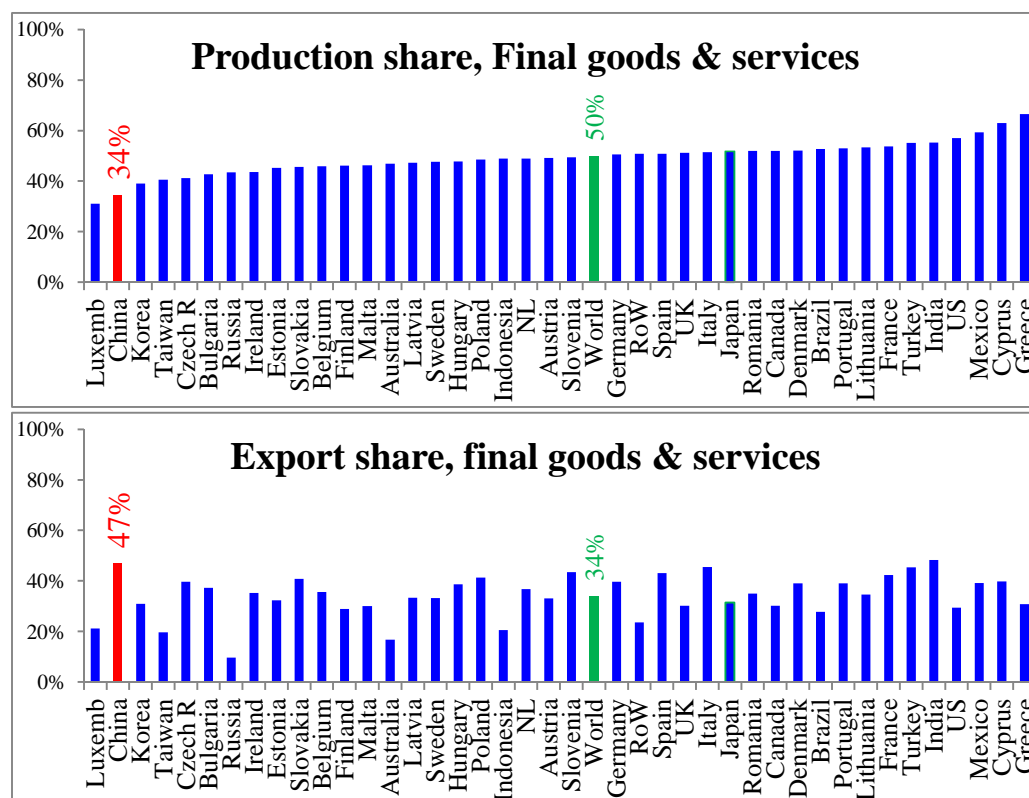
Figure 5: Final goods as share of total production & exports, by nation 2009.
Source: www.WIOD.org and authors' calculation.

The bottom panel shows how much of nations' exports are made up of final goods and services. Here we see that only 34% of exports are intermediates; as this exceeds the 50% production share, we know that trade in final goods is more open than trade in intermediates. Or to put it differently, the 2nd unbundling still has a long way to go.

Figure 6 shows the final production shares by sector for the world, again using WIOD data. It shows the importance of final sales by sectors, aggregating across all nations. The intermediate shares are the balance between 100% and the final-good shares. The sectors at the top and bottom of the left panel are, respectively, the classic final-good sectors and raw material sectors. For food, footwear and services, almost 2/3rd of production goes to final consumption. For mining and non-metallic metals, the final goods share is negligible. The big

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[3] Other sources that have commonly been used in the literature include: the Asian Input-Output Table (IDE-JETRO); the GTAP database; and the OECD inter-country IO Database.

supply-chain trade flows are in the in-between sectors like transport equipment, electrical and optical equipment and chemicals. To provide perspective on the size of the sectors, the right panel shows the global export shares by sector (taking finals and intermediates together).

The left panel also shows that the final-good shares have retreated in all sectors from 1995 to 2009. This is evidence that supply chains have fragmented across the board. Note that if every stage of production is done in a single factory, the final share would be 100%; as the production process unbundles, the final share falls whether the unbundled stages are offshored or not.
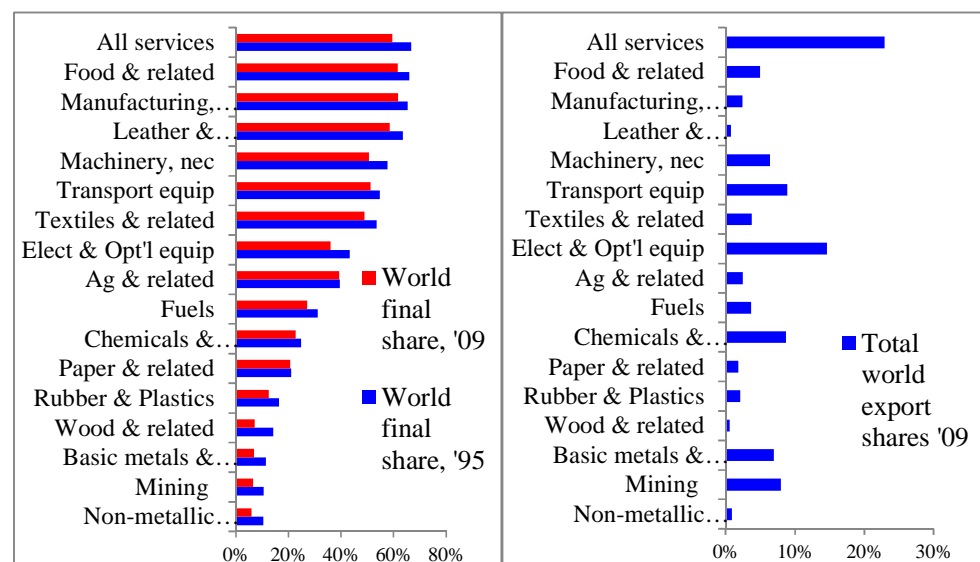
Figure 6: Final-good production and world export shares by sector.
Source: www.WIOD.org and authors' calculation.

The importance of intermediate trade in industrial goods, services, and natural resources is shown in Table 1. The remarkable point here is the very large and growing share of services. Such flows have long been under appreciated due to the lack of systematic data – especially when compared to the abundance of data on trade in goods.

Table 1: Intermediate trade by sector: Manufactures, services and natural resources

	1995	2009
Manufactures	61%	52%
Services	24%	28%
Natural resources	15%	20%

Source: www.WIOD.org and authors' calculation. Note: Natural resources as the WIOD sectors c1, 2, 3 and 8; Services are C17 – C35.

2.1.2. I2E versus value-added trade: Conditioning facts

Importing-to-export, I2E, figures work with trade as measured by customs authorities; factor-content trade is calculated using the global input-output matrix to trace all value added to its origin. As it turns out, differences between the two are not enormous for many nations (Koopmans, Wei and Zhang 2012).[4] There is a very simple reason for this – world production is not very globalised.

Table 2: Input decomposition of global GDP and global manufacturing GDP, 2009.

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[4] One of the biggest and most policy-sensitive differences is in the US-China bilateral relationship as so many nations export to the US indirectly via China given China's comparative advantage in final-good assembly.

	Manufactures		All goods & services	
	$ trill	Share	$ trill	share
Domestic value added	7.2	29%	55.3	49%
Domestic inputs	13.9	55%	47.8	43%
Imported inputs	4.1	16%	9.3	8%

Source: Raw data from www.WIOD.org

Total output is, by definition, the sum of domestic and imported intermediates and direct domestic value added. Table 2 shows that global manufacturing is not very internationalised. The imported intermediates share of total manufacturing output is only 16%; for all output, it is just 8%. While 16% is far from a tiny number, it does not jive with the world-is-flat rhetoric. Remember that in a Helpman-Krugman world, each nation uses its own intermediates in proportion to its share of world GDP. Even for the largest nation (US) that would imply an imported intermediates share of about 75%.

The large difference between the imported intermediates share for manufactures (which are systematically more traded) and all output is one reason it is important to distinguish between I2P and I2E. It also indicates that national output mixes are quite different than their export mixes. Obviously non-traded services are important, but investment and construction are also an important source of discrepancy for fast growing nations.

A good deal of the closed-ness of manufacturing stems from the fact that most manufacturing is done in large economies that tend to be rather closed and thus self-sufficient in intermediates. Today about 60% of the world's manufacturing GDP is produced inside the US, China, Japan, Germany and India.

Table 3: Sales destination of manufactured goods, 2009.

	Domestic sales		Exports	
	$ trill	%	$ trill	%
Manufactured final goods	4.4	56%	3.4	44%
Manufactured intermediates	13.1	73%	4.8	27%

Source: Raw data from www.WIOD.org

As Table 3 shows, the world is more globalised when it comes to manufactured final goods than it is for manufactured intermediates. 44% of manufactured final goods are exported while the figure is only 27% for intermediates. Despite this, intermediates are more important than final goods in exports; almost 60% of manufactured exports comprise intermediates rather than final goods. The dominance is even greater for domestic sales.

2.2. Conditioning facts: Global manufacturing and its evolution

Supply-chain trade is first and foremost a story of manufacturing. We set the scene with the conditioning facts on the evolution of the world's spatial distribution of manufacturing.

2.2.1. National manufacturing value added

In 1970, global manufacturing output was dominated by the G7; the US, Germany and Japan alone accounted for 52% of global manufacturing value added. From Figure 7 we see:

- The G7 nations lost 24 percentage points of world share from 1970 to 2010 – dropping from 71% of world manufacturing to 46% – with 18 of the 24 points lost since 1990.

- The big gainers were China and Korea; they saw their combined share rise by 21 percentage point since 1970 with 17 of these percentage points being added since 1990 (China's and Korea's overall gain were 18 and 3 respectively).
- Five other developing nations also saw their individual shares of global manufacturing rise by one percentage point or more (India, Indonesia, Thailand, Turkey and Poland); together, these '5 risers' gained four percentage points of global manufacturing; with three of the four happening since 1990.

The whole rest of the world saw little change with no nation gaining or losing more than 1% of global manufacturing. Many developing nations saw small rises (although important for each nation, they were small by world standards) and all non-G7 rich nations lost shares. On balance, this group of small gainers and losers lost two percentage points from 1970 to 2010.
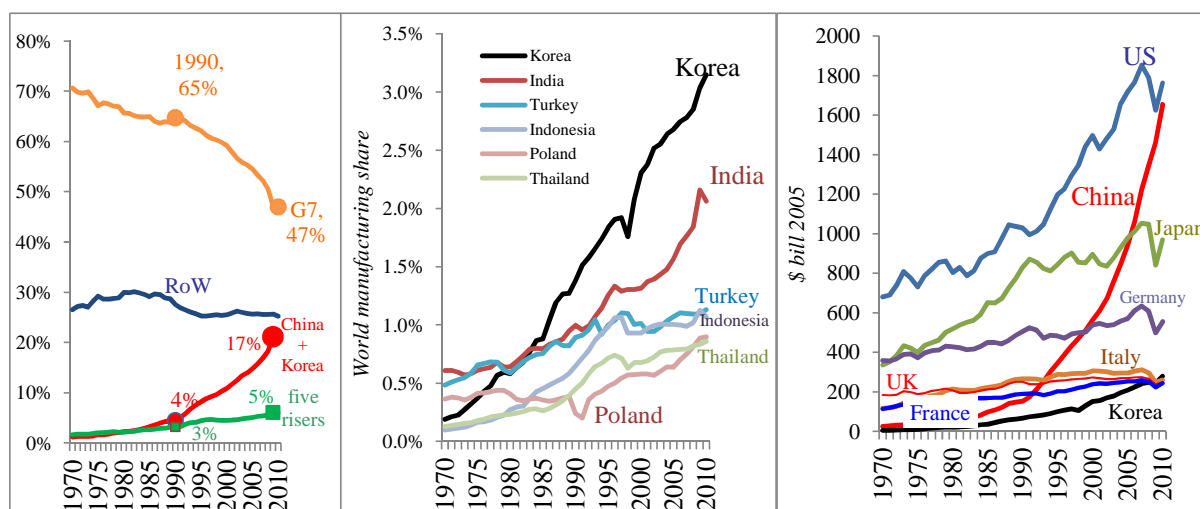
Figure 7: Seven risers and seven losers: Manufacturing reversal of fortunes.

Source: UNSTAT.org; Note: Left panel show share of world manufacturing GDP, seven risers are China, Korea, India, Turkey, Indonesia, Thailand and Poland; seven losers are G7; middle panel plots manufacturing GDP in 2005 USDs; right panel shows manufacturing GDP of G&+China (2005 USDs).

The middle panel of Figure 7 shows the numbers the '7 rises' since 1970; China is set aside since its rise is so spectacular that including it would make it impossible to see the rise of the others. The right panel shows the level of manufacturing GDP for China, Korea and the G7 nations. Here the astounding performance of China is clear. It also shows the G7 share-loss corresponds to rising levels manufacturing output (apart from the Great Recession of 2008-2009).

Box 1:What is vertical specialisation trade?

Importing-to-export (I2E) trade has been much discussed since the seminal paper by Hummels, Rapoport and Yi (1998) – often under the moniker "VS trade" ('vertical specialisation'). We avoid this label as it is confusing in three ways. First, most VS trade is horizontal in the sense of being within the same sector. Second, much VS trade is horizontal in the sense of taking place among nations at similar levels of development (e.g. US-Canada trade in car parts). Thus VS trade confusingly encompasses two-way trade in goods with similar factor contents (France and Germany) with those with dissimilar contents (US and Mexico).
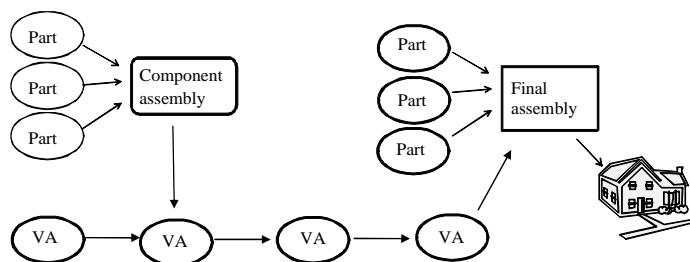
Figure 8: 'Snake' and 'spider' supply chains.

Source: Baldwin and Venables (2012)

Third, production processes are not typically linear so 'vertical' is ill-defined. While there have been some clever attempts to shoehorn non-linear input-output relationships into a liner ranking (Antras et al 2012), even the most casual inspection of input-output tables shows this lack of linearity is pervasive.

The misleading nature of the 'vertical' moniker can be illustrated even more directly with a stylised production network (Figure 8). Some parts of the illustrative network follow the classic assembly-line arrangement (called 'snakes') where a product undergoes sequential processing (bottom of the diagram). The notion of 'vertical', i.e. upstream, is clear for such chains. However, the process also involves segments where 'vertical' is ill-defined. The upper left corner shows the assembly of parts into a component that enters the second stage (called 'spiders').[5] These parts and the first link in the snake both are equally upstream.

Box 2: Supply chain trade data

As supply-chain trade concerns goods that will be inputs into production processes in other nations, the missing information on the final-or-intermediate usage is the central problem to be solved when it comes to data. It is also why the facts on the global pattern of supply chain are not widely appreciated – you cannot just download the data. There are three ways to solve the central problem.

Many authors address the 'usage' problem by turning to the customs classifications themselves (Yeats 1998, Kimura and Ando 2004, Athukorala and Yamashita 2006, Athukorala, Yamashita and Nobuaki, 2006). For example, many HS codes include descriptors like 'parts' or 'components'. However this is not fully satisfactory. Some parts – say spare tires for autos – can be intermediates (inputs into new cars) or final goods (replacement parts for old cars), and many intermediates cannot be clearly identified from the HS labels. This is especially a problem in electronics as the 1997 Information Technology Agreement's elimination of tariffs on 90% of world trade removed custom authorities' incentive to be precise about the nature of such imports.

A second approach is to turn to input-output tables that keep track of usage explicitly – although this tactic always comes at the cost of less disaggregation in product categories. This tactic has recently be adopted by many authors (Hummels, Ishii, and Yi 2001, Yi 2003, Bems, Johnson, and Yi 2010, Koopman, Powers, Wang, and Wei 2011, Johnson and Noguera 2012a,b). For some nations, we have a third solution since there is data from special customs regimes for 'processing trade'. This is where tariffs on imported intermediates are suspended if all the intermediates are used to make goods that are subsequently exported so customs keeps track of the imported intermediates thus used (Cernat and Pajo 2012, and Koopman, Robert, Zhi Wang, and Shang-Jin Wei 2008).

Knowing a good's usage is just one side of the supply-chain trade data problem – call it the 'sales side'. The other side is the 'sourcing side'. The value of every good sold is built up from the producing nation's value added (i.e. input of primary factors capital, labour, etc.) and intermediates; this is an accounting identity.[6] On the sourcing side, we must distinguish between intermediates that are imported versus locally sourced.

Once we have the sales-side and sourcing-side usage data, we can paint a picture of international production networks. Final goods are made of local primary factors, and local and imported intermediates which themselves include intermediates sourced locally and abroad.

See Box 3 for details.

[5] Spider comes from the way the parts in the diagram resemble legs on a body.
[6] By definition, the home value added is the difference between sales price and the cost of the intermediate inputs including raw materials, purchased intermediate goods and services.

Box 3: A schematic presentation of supply chain concepts

Figure 9 focuses on a single nation "Home" and its import and export baskets as traditionally measured by customs authorities. A first key distinction is between final goods and intermediates. Final goods and services are sold for private consumption, government consumption, or investment (house at the top of the diagram labelled "Home final use"). Intermediates are used as inputs into the production of goods and services ('Home factories and offices" at bottom of diagram).

Exported final goods remain in the destination country; intermediates may not. The diagram distinguishes between final and intermediate output with the two thick arrows inside the factory, and the two separate wide arrows in the import and export baskets. Importantly, the final versus intermediate distinction cannot be drawn from traditional trade data; end-use is not specified in customs forms. Car tires, for example, can be used for new cars (intermediate) or replacements for existing cars (final).

A second key distinction is between factor inputs (value added) and intermediate inputs. By definition, the value of Home's output is the sum of Home value added and intermediate inputs, both domestic and imported.

A third key distinction is local versus export sales. Crossed with the end-use distinction, we get four groups: Home finals sold locally or abroad, and Home intermediates sold locally or abroad. These four possibilities are shown with the narrow connector arrows leaving the right side of the factory.

The final key distinction is between sales and sourcing of intermediates. I2P on the sourcing side reflects a nation's import of intermediates; on the sales side, it reflects exports of intermediates. For many nations, the sales and source patterns differ in important ways.[7] The geographical patterns on both sales- and sourcing-sides are interesting and informative but involve no unfamiliar terminology.

As we wish to track further international movement of Home exports, the export basket is represented with a wide arrow divided into final goods and services (light blue) and intermediate goods and services (light red). The three-way composition between Home value-added, Home intermediates and imported intermediates is shown within each arrow.
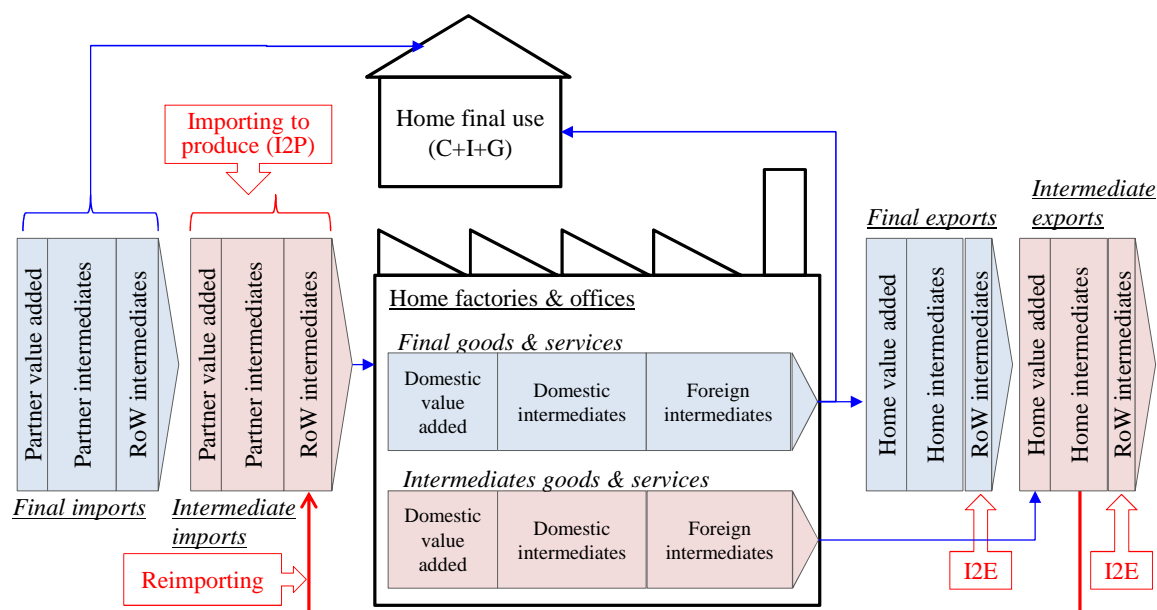
Figure 9: Schematic diagram of trade in final and intermediate goods.

Turning to the import basket, we have the same breakdown with the arrows on the left side showing value added (from the partner nation that Home is importing from), intermediates produced in partner, and intermediates produced in the rest of the world (RoW). Importing-to-produce and importing-to-export trade are indicated by the boxed arrows in the upper left and lower right corners.[8]

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[7] ; Russia, for example, sells natural resources to international supply chains while sourcing manufactured inputs from them.

[8] I2P differs from standard imports for various reasons. For example, the demand is not governed by national expenditure (expenditure function), but rather gross production (cost function).This has implication for gravity estimation; see Baldwin and Taglioni (2011).

Recombination of the I2E concept

The I2E concept is recursive, so double counting is pervasive. For example, the imported intermediates in Home's exports may embody some previously exported Home intermediates. There are two ways to deal with this. Both are illuminating.

Stay with trade as traditionally defined (value of goods and services as they cross borders) and identify the share of such trade that crosses borders more than once; or

Abandon traditional trade definitions by tracing back the ultimate source of primary factor inputs (factor-content trade).

Staying with traditional trade concepts helps us understand the trade patterns we observe in today's world and helps when explaining the implications to policy makers. The focus stays on goods and where they are made. Moreover, it is closer to 'real' data in that it involves a limited number of estimated coefficients (e.g. share of Home's own intermediates embodied in Home's imported intermediates).

Moving to factor-content trade gets us to the real picture of global production sharing. The emphasis is shifted away from goods and towards the location of labour and capital tied to the sale of final goods. Unfortunately, factor-content trade involves working with series that are 100% calculated rather than observed. Working out the factor-content by country of origin involves almost every estimated coefficient of almost every nation's input-output matrix. Since the quality of the estimation varies widely across nations, estimates of value-added trade are distinctly shakier than those of importing-to-export trade.

Reimporting and reexporting

One popular recombination of I2E trade is called 'reimporting'. This is essentially the trade 'symptom' of the offshoring of a single stage of production. It concerns a nation's intermediate exports that are embedded in goods it subsequently imports; see the boxed arrow in diagram's lower left side of Figure 9. An example of reimporting trade is the US-Mexico Maquiladora trade (the US exports intermediates to Mexico and subsequently imports them back to the US embedded in goods that have been further processed). Reexporting is the mirror concept. For Maquiladora trade, the US intermediates in the exports from Mexico to the US are US reimports and Mexican reexports.

The connection between offshoring and reimporting/reexporting can be more complex. For example Japanese camera companies import simple industrial parts from China as inputs into sophisticated components that they then ship to China for assemble into final cameras. When measured by reimporting/reexporting, we would see the same pattern whether it was the Japanese company doing to offshoring to China of simple parts and assembly, or a Chinese camera company offshoring the sophisticated component to Japan. One recombination of I2E that picks this up is 'triangle trade', or indirect exports (more on this below).

3.   IMPORTING-TO-PRODUCE (I2P) TRADE: THE WORLD PATTERN

This section highlights the key facts concerning I2P trade and its evolution.

3.1.   World I2P matrix diagram

To illustrate global pattern, we employ a matrix that shows the flow of supply-chain trade among the nations for which the WIOD has harmonised IO tables. Each element of matrix shows the row-nation's imports of intermediates from the column-nation. To focus on the big picture, we zero-out any bilateral flow that is less than 3 tenths of 1% of all the trade among the listed nations. We also hide the rows and columns for several tiny nations in the sample (Cyprus, Malta, Lithuania, Denmark, etc.). The rows and columns are arranged to reflect regions. Europe is at the top, North America at the bottom and Asia and other nations are in between.

Focusing on 2009, the most recent year, Figure 10 shows the global I2P pattern. The most salient features are:

- The matrix is very sparse; very few bilateral flows are significant on a global scale.

- The US, China, Germany, and Japan dominate global supply chain trade.

These are the only nations who supply a globally significant amount of intermediates to more than four partners. On this metric, Germany is by far the most significant, but this surely reflects the WIOD's bias towards European nations (24 of the 40 nations) rather than reality. From other sources (see Section 4.2), we know that supply-chain trade among Japan, Korea, China and other large East Asian nations (Philippines, Malaysia, Thailand, Singapore, Vietnam, and Taiwan) is very important. Among the other G7 nations, the UK has 4 entries, and Canada and France have one. Italy has none. Note that non-European exports to Germany often show up as imported into ports-of-entry (Antwerp and Rotterdam) in Belgium and the Netherlands.[9]

The third feature is well known among specialists (Johnson and Noguera 2012b):

- Supply chain trade is not global – it's regional.

'Global supply chains' is a great buzzword but it is inaccurate in aggregate. Even within regions, distance, and contiguity seems to matter enormously.

- The global production network is marked by regional blocks, what could be called Factory Asia, Factory North America, and Factory Europe.

The off-block exceptions all involve one of the four giants as seller or buyer (apart from the tight UK-Irish link). Turning to the regional 'factories', we see:

- The most intensive supply-chain trade relationships are in North America.

US I2P trade with Mexico and Canada are both over 1% of the world total. US imports from China and Mexico are the two largest I2P flows globally (2% each).

- The I2P trade in Northeast Asia is almost as intense as North America's.

The notion of an Asia-Pacific region also emerges from the matrix. The trade between US and Japan and China easily passes the 0.3% threshold.

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[9] To avoid VAT fraud inside the EU, third-nation products for Germany often enter into commerce at the port of entry (Baldwin 2006c)

I2P '09

I2P '09	UK	Germany	France	Itlay	NL	Belgium	Austria	Poland	Czech	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taipei	China	Japan	Korea	US	Mexico	Canada	RoW
UK		0%			0%										0%												0%			1%
Germany	0%		1%	0%	0%		0%																	1%			0%			2%
France		0%																												1%
Itlay																														1%
NL		1%				0%																								0%
Belgium		0%																												
Austria																														
Poland																														
Czech																														
Denmark																														0%
Spain																														0%
Portugal																														
Finland																														
Greece																														
Ireland																														0%
Turkey																														0%
Sweden																														0%
Brazil																														0%
Russia																														1%
India																														0%
Indonesia																														0%
Australia																								1%						0%
Taipei																								1%						0%
China		1%																		0%					1%	1%	2%			4%
Japan																								1%		0%	0%			2%
Korea																								1%						1%
US	0%	0%																						1%	0%			1%	1%	4%
Mexico																											1%			
Canada																											2%			
RoW	1%	1%	1%	1%	1%					0%				0%					0%	1%	0%	0%	0%	4%	2%	1%	3%			

Total '09

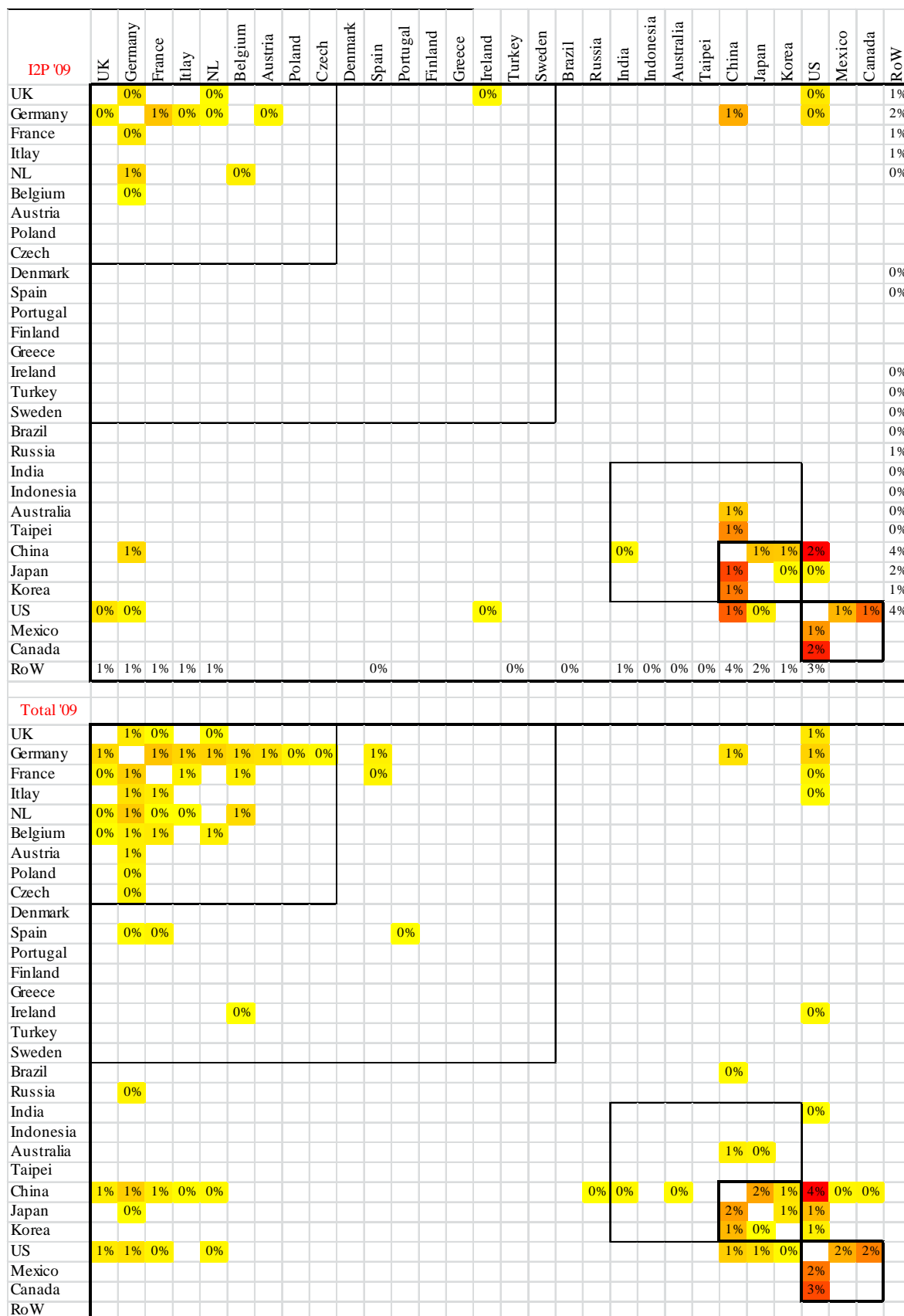| Total '09	UK	Germany	France	Itlay	NL	Belgium	Austria	Poland	Czech	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taipei	China	Japan	Korea	US	Mexico	Canada	RoW
UK		1%	0%		0%																						1%			
Germany	1%		1%	1%	1%	1%	1%	0%	0%						1%									1%			1%			
France	0%	1%			1%										0%												0%			
Itlay		1%	1%																								0%			
NL	0%	1%	0%	0%		1%																								
Belgium	0%	1%	1%		1%																									
Austria		1%																												
Poland		0%																												
Czech		0%																												
Denmark																														
Spain		0%	0%									0%																		
Portugal																														
Finland																														
Greece																														
Ireland						0%																					0%			
Turkey																														
Sweden																														
Brazil																								0%						
Russia		0%																												
India																											0%			
Indonesia																														
Australia																								1%	0%					
Taipei																														
China	1%	1%	1%	0%	0%															0%	0%		0%		2%	1%	4%	0%	0%	
Japan		0%																						2%		1%	1%			
Korea																								1%	0%		1%			
US	1%	1%	0%		0%																			1%	1%	0%		2%	2%	
Mexico																											2%			
Canada																											3%			
RoW																														

Figure 10: The global I2P trade & total trade matrices, 2009.

Notes: Top panel: Bilateral purchases of intermediates by row nation from column nation as % of all I2P flows in WIOD data base; flows under 0.3% set to zero. Bottom panel: total bilateral trade normalised same way.

Another fact that is well established among specialists (Johnson and Noguera 2012a) is:

- I2P trade is marked by a hub-and-spoke pattern around the four manufacturing giants – China, Germany, Japan and the US.

This can be most easily seen in North America where the sales and sourcing flows with the US are all large, but those between Mexico and Canada are small. The same holds for Germany (its row and column are rather full especially in Europe).

A key distinction that is less well appreciated—and one that we return to repeatedly below -- is the technological asymmetry in the international production network whereby there are 'headquarter economies' and 'factory economies'.[10] Firms in the headquarter economies (mostly the US, Japan and Germany) arrange the production networks; factory economies provide the labour.

The nations not in the sample (RoW) are important taken as a whole. Particularly important on the sales-side are the world's energy and food producers (OPEC nations, Argentina, etc.). On the sourcing-side, noticeable omissions include the large ASEANs (Malaysia, Thailand, and the Philippines).

Total trade: Global pattern

For comparison, the bottom panel shows the same matrix with the same filter for total trade, i.e. with finals and intermediates included. The most noticeable differences are:

- The total trade matrix is far less sparse, especially within regions.
- The hub-and-spoke pattern is less pronounced for total trade than supply-chain trade.

This suggests that supply-chain trade is more sensitive to distance than final good trade (Gamberoni et al 2010, Lopez-Gonzales 2012). This may be since face-to-face and face-to-machine interactions are necessary but these are costly in terms of lost time and highly sensitive to distance (Baldwin 2006a).

3.2. Supply-chain interdependency

The matrices presented above take the global perspective – looking only at flows that are significant at the global level. Here we look at the national level, focusing on where each nation sources its intermediate inputs. In a sense, this reveals each nation's dependency on international supply networks.

The numbers for 2009 are shown in Figure 11. Each column adds up to 100% and thus shows each column nation's purchasing pattern (numbers under 2 percent are zeroed to reduce clutter). A few facts jump out of the matrix:

- Most nations are largely self-sufficient in terms of intermediate inputs.

Local sourcing numbers (on the diagonal) are all above half and many are about 70%. As expected, there is a rough correlation between size and self-sufficiently with three of the Giant-4 manufacturers attaining local sourcing ratios of around 90%. Germany is the exception, relying on itself for only 79% of purchased inputs.

- European nations are heavily dependent on German intermediates.

Every European nation except Spain, Italy and Russia rely on Germany for at least 2% of their national intermediate purchases.

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[10] See Baldwin (2006b) for a fuller analysis of the distinction.

- The US and China play similarly pivotal roles but with less regional focus; the US is an important supplier in all regions, while China is more focused on Asia.

As an aside, we can see that the WIOD coverage is far from complete since the Rest of World row contains a great number of entries over 2%.

2009	UK	Germany	France	Italy	Austria	Belgium	Bulgaria	Cyprus	Czech R	Denmark	Spain	Estonia	Finland	Greece	Hungary	Ireland	Lithuania	Luxemb	Latvia	Malta	NL	Poland	Portugal	Romania	Russia	Slovakia	Slovenia	Sweden	Brazil	Australia	Turkey	China	Japan	Korea	Taiwan	Indonesia	India	Mexico	Canada	US	RoW
UK	82							2		2						12		22			5	4																			
Germany		79	3		10	5	2	2	8	5		3	3	3	9	2	3	6	2	3	4	5	2	4		6	5	3													2
France			84		3													4					3					4													
Italy				85		3									3			4						7			2	4													
Austria					72										3													3													
Belgium						66												7			3																				
Bulgaria							75																																		
Cyprus								71																																	
Czech R									72																	4															
Denmark										70																		2													
Spain											85												6																		
Estonia												70																													
Finland												3	78																												
Greece									3					72																											
Hungary															59																										
Ireland																54																									
Lithuania																	62		3																						
Luxemb																		38																							
Latvia																			78																						
Malta																				61																					
NL					7					3								3			67																				
Poland																	3					77																			
Portugal																							80																		
Romania																								77																	
Russia									5			2	2	2	2		17		2						93	4					2										
Slovakia																										66															
Slovenia																											69														
Sweden										3		2																73													
Brazil																													92												
Australia																														89											
Turkey																															82										
China									3						4		3				4	3									2	88	4	5	3		3	4			5
Japan																																	92	2	5						
Korea																																		78							
Taiwan																																			68						
Indonesia																																				85					
India																																					85				
Mexico																																						76			
Canada																																							81		
US	2							2		3				2	2	12	3				3											2	3					11	10	91	5
RoW	4	3	3	4	4	4	4	3	2	4	3	5	3	7	3	6	4		4	6	7	2	4	3	5	5	4	3	4	6	4	4	7	11	6	7			2	3	73

Figure 11: I2P sourcing: National dependency on imported intermediates, 2009 (%).

Source and notes: see Figure 9. Numbers under 2% are zeroed.

3.3. I2P trade by sector: Industrial goods, services and natural resources

The matrices above looked at aggregate I2P trade; here we break this down into: industrial goods, services and natural resources. To put these in context, we start with aggregate facts (Table 4).

In 1995 over 60% of all intermediate trade was in industrial goods – a figure that fell to just over 50% by 2009. The slack was taken up largely by natural resource (15% to 20%) but service intermediates also became more important (24% to 28%). Of course, part of the shift in natural resources reflects the important terms-of-trade shifts that favoured this sector since the late 1990s, but the numbers implies:

- Between 1995 and 2009, supply chain internationalisation has been more important in services and natural resources than it has been in industrial goods.

The second set of facts concerns the level and change in self-reliance for inputs (Table 5). As

mentioned above, the world production is still not very globalised:

- Supply-chain trade is on average only a small part of global production; goods are the most globalised and services the least with natural resources in between.

Table 4: Supply-chain trade (I2P): Goods, services and natural resources.

	1995		2009	
	$ million	%	$ million	%
Goods	2,079,634	61%	4,847,792	52%
Services	820,507	24%	2,622,469	28%
Natural Resources	519,333	15%	1,875,734	20%
Total	3,419,474		9,345,995	

Note: current prices; source: WIOD.org

Table 5: Share of intermediates sourced domestically, 1995 and 2009, goods, services and natural resources.

	1995	2009
Goods	77%	73%
Services	94%	91%
Nat.Res	85%	80%

Note: current prices; source: WIOD.org

As expected, all the own-sourcing shares fell, but even in 2009 the figure for own sourcing of intermediate services trade is about 90% – a fact that shows just how far services trade has to go before it becomes as globalised as goods trade. This casts doubts on the idea, popularised by Alan Blinder (2006), that offshoring of services is about to transform the employment landscape in high-wage nations.

3.3.1. Intermediate industrial goods and services

To see the global pattern of I2P trade in industrial inputs, we plot the data in a matrix constructed like Figure 10 but where only industrial inputs are included in the flows; here industrial goods means goods other than agriculture, mining, food, and fuel[11]. Figure 12 (top panel) shows the facts. The first thing to note is:

- I2P trade in industrial goods is similar to total I2P trade (Figure 10 top panel), but the hub and spoke pattern is stronger and the dominance of the Giant-4 manufacturers is even greater.

One change is that China is more dominate – again not surprising given the common perception that China's exports comprise mainly manufactured goods.

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[11] Formally the goods not included are, using WIOD sector labels Agriculture, Hunting, Forestry and Fishing; Mining and Quarrying; Food, Beverages and Tobacco; and Coke, Refined Petroleum and Nuclear Fuel.
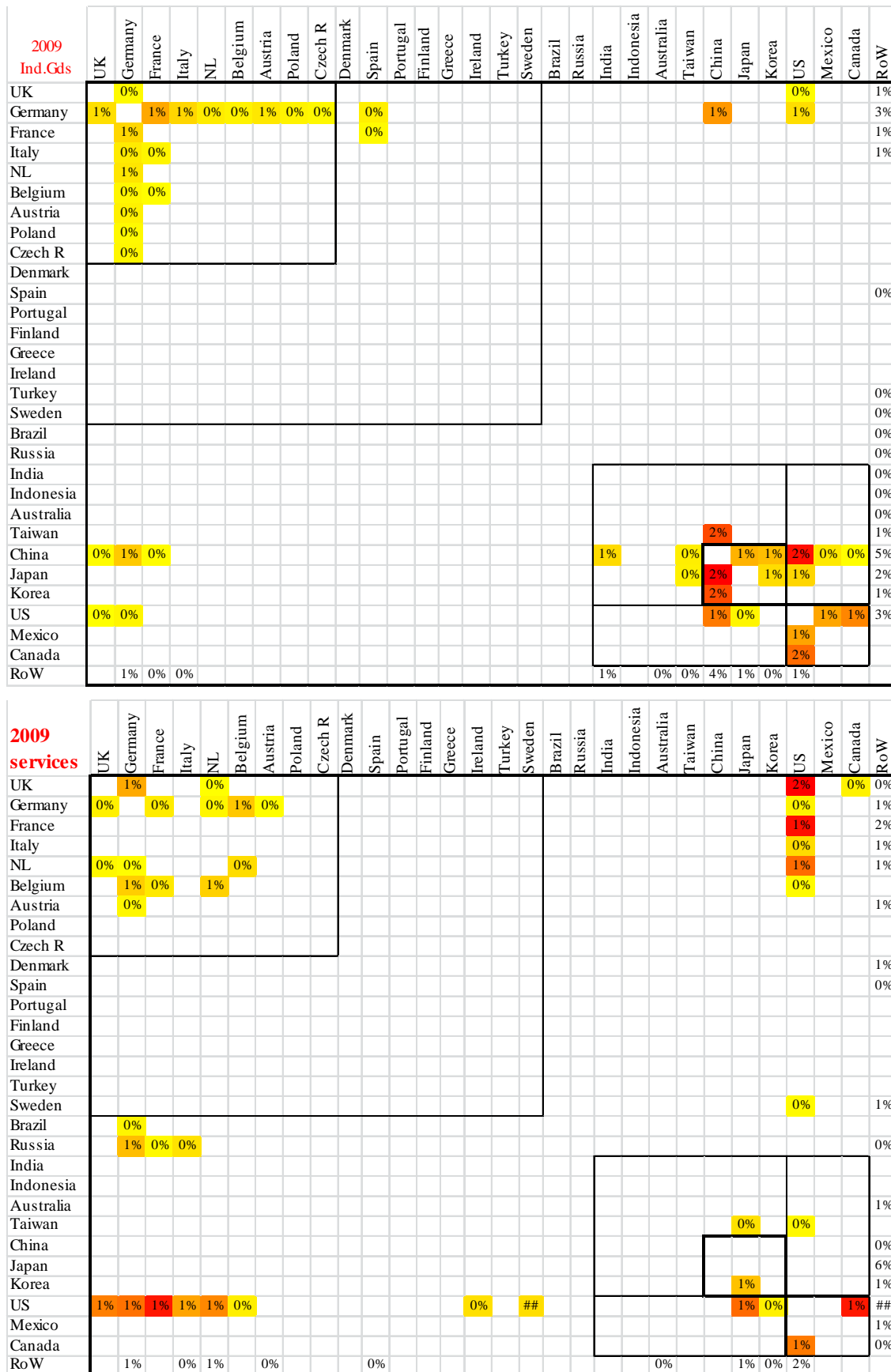
2009 Ind.Gds

	UK	Germany	France	Italy	NL	Belgium	Austria	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taiwan	China	Japan	Korea	US	Mexico	Canada	RoW
UK		0%																									0%			1%
Germany	1%		1%	1%	0%	0%	1%	0%	0%		0%													1%			1%			3%
France		1%									0%																			1%
Italy		0%	0%																											1%
NL		1%																												
Belgium		0%	0%																											
Austria		0%																												
Poland		0%																												
Czech R		0%																												
Denmark																														
Spain																														0%
Portugal																														
Finland																														
Greece																														
Ireland																														
Turkey																														0%
Sweden																														0%
Brazil																														0%
Russia																														0%
India																														0%
Indonesia																														0%
Australia																														0%
Taiwan																								2%						1%
China	0%	1%	0%																	1%			0%		1%	1%	2%	0%	0%	5%
Japan																							0%	2%		1%	1%			2%
Korea																								2%						1%
US	0%	0%																						1%	1%			1%	1%	3%
Mexico																											1%			
Canada																											2%			
RoW		1%	0%	0%																1%	0%	0%		4%	1%	0%	1%			

2009 services

	UK	Germany	France	Italy	NL	Belgium	Austria	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taiwan	China	Japan	Korea	US	Mexico	Canada	RoW
UK		1%			0%																						2%		0%	0%
Germany	0%		0%		0%	1%	0%																				0%			1%
France																											1%			2%
Italy																											0%			1%
NL	0%	0%			0%																						1%			1%
Belgium		1%	0%		1%																						0%			
Austria		0%																												1%
Poland																														
Czech R																														
Denmark																														1%
Spain																														0%
Portugal																														
Finland																														
Greece																														
Ireland																														
Turkey																														
Sweden																											0%			1%
Brazil		0%																												
Russia		1%	0%	0%																										0%
India																														
Indonesia																														
Australia																														1%
Taiwan																									0%		0%			
China																														0%
Japan																														6%
Korea																									1%					1%
US	1%	1%	1%	1%	1%	0%									0%		##								1%	0%			1%	##
Mexico																														1%
Canada																											1%			0%
RoW		1%		0%	1%		0%								0%							0%			1%	0%	2%			

Figure 12: The global I2P trade in industrial goods and services, 2009.

Source and notes: see Figure 10.

Turning to services (bottom panel), we see much larger differences:

- China and Japan are not important players in supply-chain services trade on either the sales side (row) or the sourcing side (column).
- The US is a much more dominant player in I2P services trade than in goods.

Much of this trade is trans-Atlantic; US purchases from and sales to EU nations are all large compared to global services trade in intermediates. Moreover:

- Intermediate services trade inside Factory Asia is very limited;
- Intermediate services trade inside Factory Europe is at least as important as intermediate goods trade, but the role of Germany is greatly reduced;
- A few of the smaller European nations are important providers of intermediate services both inside Europe and to the US;
- The world pattern of trade of service inputs is far less regionalised than it is for goods.

3.3.2. Natural resource inputs

The picture for natural resources is much simpler at least in part due to the biased coverage of the WIOD sample. Few of the nations in the WIOD sample are major exporters of natural resources. To reflect this, we use a lower zeroing limit of 0.1% rather than 0.3% as in the previous matrices.

Russia, Indonesia, US, Canada and Mexico are the only nations in the WIOD sample who are important on the sales-side of natural resource inputs. The important nations on the sourcing side are the largest nations in the sample – the G7 nations (except Britain), China and Korea. In this matrix, the RoW row is especially important since it includes all the OPEC exporters, and major suppliers of minerals and food. Nearly 28% of total natural resource exports are absorbed by China, the US, Japan and Korea.

2009 Nat'l Resources	UK	Germany	France	Italy	NL	Belgium	Austria	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taiwan	China	Japan	Korea	US	Mexico	Canada	RoW
UK																														
Germany																														0%
France																														
Italy																														
NL		0%				0%																								0%
Belgium																														
Austria																														
Poland																														
Czech R																														
Denmark																														
Spain																														
Portugal																														
Finland																														
Greece																														
Ireland																														
Turkey																														
Sweden																														
Brazil																								0%						0%
Russia				0%																				0%						0%
India																														
Indonesia																								0%	0%					0%
Australia																								0%	0%					0%
Taiwan																														
China																														0%
Japan																														
Korea																														0%
US																								0%	0%			0%	0%	0%
Mexico																											0%			
Canada																								0%			1%			0%
RoW	0%	0%	0%	1%	0%					0%					0%		0%	0%	0%	0%	0%			2%	1%	1%	2%		0%	

Figure 13: The global I2P trade in natural resources, 2009.

Source and notes: see Figure 10.

3.3.3. Two types of emerging economies

The sector level facts hint at a vast shift in global production structures somewhat akin to that which took place during the first wave of globalisation (say 1850-1910; see Baldwin and Martin 1999). Manufacturing has shifted from the G7 – especially the three old giants (US, Germany and Japan) – to a handful of developing nations who are within commuting distance from the three old giants, with China the most spectacular gainer. The rapid income growth sparked by industrialisation in the manufacturing-based 'emerging economies' has sparked an export boom from natural-resource abundant countries. This in turn sparked rapid income growth in the resource-rich developing nations. In this way, the manufacturing success of a narrow group of emerging economies (China, Korea, etc.) is linked to the success of resource-based emerging nations (Russia, Brazil, etc.). In the face of this shift, G7 countries are turning increasingly to the export of intermediate services – especially those linked to manufacturing.

3.4.   Changes since 1995

To compare today's pattern with the pattern when the 2nd unbundling had just started rolling, we compare the Figure 10 matrix with a similar one with data from 1995. To facilitate comparison, we plot the percentage point differences for each element (Figure 14). Negative elements are in blue and positive elements are in red. To focus on big changes, we zero-out all changes that are between -0.3 and 0.3 percentage points.

Change, 2009 less 1995	UK	Germany	France	Italy	NL	Belgium	Austria	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Turkey	Sweden	Brazil	Russia	India	Indonesia	Australia	Taipei	China	Japan	Korea	US	Mexico	Canada	RoW
UK																											-0.4			
Germany	-0.4		-0.4	-0.3	-0.3	-0.3																		0.7						
France		-0.4		-0.3																									-0.4	
Italy		-0.3																												
NL																														
Belgium		-0.3																												
Austria																														
Poland																														
Czech R																														
Denmark																														
Spain																														
Portugal																														
Finland																														
Greece																														
Ireland																														
Turkey																														
Sweden																														
Brazil																														
Russia																														0.7
India																														
Indonesia																														
Australia																								0.5						
Taipei																								0.6			-0.3			
China		0.4																		0.3						0.4	1.4			3.5
Japan																							-0.3	0.8			-1.1			-2.1
Korea																								0.7	-0.3		-0.3			0.3
US			-0.4																					0.9	-0.7			-0.3	-0.8	-1.7
Mexico																														
Canada																											-0.8			
RoW																				0.6				3.6						

Figure 14: Change in global I2P trade from 1995 to 2009 (percentage points).

Notes: Numbers show change bilateral flows between 2009 and 1995 each measured in percentage of global 12P trade as in Figure 10.

The differences are not enormous at this level of resolution but a few things have changed.

- Supply-chain trade has shifted heavily towards Factory Asia and away from Factory North America and Factory Europe.

- China is the only big gainer on the sales side;
- Germany, Japan and the US all lost on the sales side with except with respect to their sales to China.

Inside Europe, the dominance of Germany faded between 1995 and 2009 both on the sales and sourcing sides.

2009 less 1995	UK	Germany	France	Italy	Austria	Belgium	Bulgaria	Cyprus	Czech R	Denmark	Spain	Estonia	Finland	Greece	Hungary	Ireland	Lithuania	Luxemb	Latvia	Malta	NL	Poland	Portugal	Romania	Russia	Slovakia	Slovenia	Sweden	Brazil	Australia	Turkey	China	Japan	Korea	Taiwan	Indonesia	India	Mexico	Canada	US	RoW
UK									-2								-3	13				1																			
Germany	-6				-2										4			-3	-2	-4	-2	2	-1		3																
France		-2			-1	-1												-1		-2																					
Italy																		2		##																					
Austria					-2													-2																							
Belgium																		##																							
Bulgaria								1																																	
Cyprus								10																																	
Czech R									-5																	-2															
Denmark										-7																															
Spain																							2																		
Estonia												4																													
Finland												-8	-2						-2																						
Greece														##																											
Hungary															##											1	1														
Ireland																-7																									
Lithuania																	-5		1																						
Luxemb																		-2																							
Latvia																			7																						
Malta																				17																					
NL											1					1					-2																				
Poland												1					2		1			##																			
Portugal																																									
Romania																								-6																	
Russia					-5	-4	-2				-3			1	-2		6				-4				1	-2	2														
Slovakia																										-9															
Slovenia																											-2														
Sweden																			-3	-1								-4													
Brazil																													-1												
Australia																																									
Turkey								1																							-3										
China	1	2			1	1	1	1	3		1	1	2	1	4	1		3				4			2	2	2		1	2	2	-3	1	3	4	2	2	4	1	1	4
Japan																		-1														-4			-2						-2
Korea																									1								-5	-1							
Taiwan																																			-6						
Indonesia																																				2					
India																																					-6				
Mexico																																						-2			
Canada												1																											4		
US											2			1		2									1	-2						-1	-2				-4	-5	-2	-2	
RoW	1	1	1	2		1			-1		1		3	1	4	1	2	-2			-2				1	1			-1		3	2	1	2	2	2	3	5	3	4	1	-3

Figure 15: I2P sourcing: Changes between 1995 and 2009 (%).

Source and notes: see Figure 9.

3.4.1. Changes in dependency

We turn next to the changes from 1995 to 2009 with respect to national dependencies on supply-chain trade (I2P). Figure 15 shows the changes between the shares in Figure 11 and the equivalent matrix for 2009. As usual, we zero small numbers to improve clarity (less than plus or minus one percentage point).

- The most striking fact is the almost universal reduction in local sourcing (diagonal elements mostly negative).

This is nothing more than an enumeration of the 2nd unbundling; more stages of production are been broken off from the home factory or industrial district and shipped abroad. The exceptions are Russia, Canada, Indonesia and some very small nations (many of them former communist economies).

- China's rise as a global supplier of intermediates can be seen in the many positive numbers in its row; this has not been accompanied by a rise as a purchaser (few positive number on its column).
- The decline of Russia as a supplier of intermediates is almost as impressive as China's rise, given the large number of negative numbers on Russia's row.
- Germany has mostly seen its role decline while the US's experience is more mixed with number falling in North America but rising in Asia.

3.5. Importing-to-export (I2E) trade: the world pattern

This section turns to a narrower concept of supply-chain trade, namely importing-to-export (I2E) or vertical specialisation as it is sometimes called.

Importantly, I2E data and I2P data differ in their distance from actual observations. I2P data is based on calibrated IO tables and thus are one step removed from observed data; I2E data is two-steps removed since the parameters of the IO table must be used to break-out the portion of I2P trade that is related solely to exporting. Specifically, a given nation's international input-output table tells us the intermediate purchases linked to a given dollar of production in a particular sector. To find the intermediate purchases linked to the nation's export vector, we pre-multiply the international IO table by the nation's export vector (after aggregating trade into sectors that match those in the IO table). The result is a vector of intermediate inputs (domestic and imported) that are embedded in the exports.

The data in this section comes from Lopez-Gonzalez (2012) which focuses on slightly different years and a slightly different sample of nations due to practical considerations discussed in Box 4.

2008 I2E	UK	Germany	France	Italy	NL	Austria	Switz	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Sweden	Brazil	Argentina	Chile	Russia	S.Africa	India	Indonesia	Australia	China	Japan	Korea	US	Mexico	Canada
UK		1	0		1																									
Germany	1		1	1	1	1	1	1	1		1									1								0		
France	0	1		0	0						0																			
Italy		0	0								1									0										
NL	0	1																												
Austria																														
Switz		0																												
Poland																														
Czech R																														
Denmark																														
Spain			0									0																		
Portugal																														
Finland																														
Greece																														
Ireland																														
Sweden																														
Brazil																		1												
Argentina																														
Chile																														
Russia		1	0	0	1		0				0		0																	
S.Africa																														
India																														
Indonesia																									0	0				
Australia																								0	1	1				
China	0	1	0		0						0								1			0	0			1	1	1	1	0
Japan																			0						1		1	1	0	
Korea																									1			0		
US	0	0	0		1							0	0												0		0		2	2
Mexico																												1		
Canada																												2		

Figure 16: The global I2E trade matrices, 2008.

Notes: Bilateral I2E; row nation exports to column nation as % of world I2E. Source: Authors' calculations on OECD IO tables (see Lopez-Gonzales 2012 for details).

3.6. The world I2E sourcing matrix in 2008 vs 1995

We start by looking at the global I2E pattern for the year 2008 using a graphic very similar to that of Figure 10. Each element shows the column nation's I2E purchases from the corresponding row nation as a percentage of world I2E trade. As usual, small numbers are zeroed. (less than 0.3% of world I2E trade). Several points are noteworthy.

- I2E trade (Figure 16) is significantly less regionalised that I2P trade (Figure 10).

First, we see many more non-zero entries in US, Chinese and Russian rows especially for intermediate exports to Europe. Second, within Europe the pattern is much less centred on Germany. Third, trans-Pacific links are stronger especially North American purchases from the three large Asian manufacturers (Japan, China and Korea).

- The asymmetry between of US, Chinese and Russia I2E on the sales side (their rows) and sourcing side (their columns) is much greater for I2E trade than I2P trade.

This means that these nations are more important as suppliers of intermediates than they are as buyers of intermediates. For the US this is likely to reflect the active outsourcing policies of US firms, while for China it is likely to reflect the highly competitive nature of their intermediate industrial goods; for Russia oil and gas exports to Europe's energy intensity sectors is most likely the explanation.

3.7. The I2E interdependency matrix, 2008

As with I2P trade, the global perspective hides many features that are important to particular nations. Here we look at the same on the bilateral I2E data but normalise it by the column nation's total purchase of I2E intermediates. The nation's purchases from itself are zeroed and added to rest of world numbers (RoW) in the row at the bottom. For clarity, table entries under 2% are zeroed to improve readability. The key points are:

- Most nations are thoroughly engaged in international production networks in that their exports depend heavily on imported intermediates

This shows up in the fullness of most nations' columns. It can also be seen in the figure in the last row which shows that even the most self-sufficient nation, Japan, imports at least 12% of the inputs they need to export. The highest number is for Mexico which source 94% of its intermediates from abroad (half from the US). As usual, there is some double counting here is some of the Mexican imports from the US include Mexican intermediates.

The main providers of intermediates essential to exporting are, as expected, the Giant-4 manufacturers – the US, China, Japan and Germany.

- All non-European nations are heavily reliant on Chinese intermediates and seven of the 16 listed European nations also get more than 2% of their total I2E from China.

Germany and the US are almost as dominate but Japan is a key supplier to less than half the nations that China is.

- The I2E interdependency matrix if far less sparse than the I2P interdependency matrix (Figure 11) suggesting that international production networks aimed at exports is more developed than those aimed at domestic production.

This can be seen in the fullness of many rows in Figure 17. Nations such as Sweden, Switzerland, Poland and the large European nations (UK, Germany, France, Italy, and Netherlands) are key suppliers to multiple partners. The reliance of European nations on Russian raw materials is also very clear in the matrix.

- China plays a very asymmetric role in intra-BRICS (Brazil, Russia, China and South Africa) I2E trade; China is a major supplier to the other four, but none is a major suppliers to China.

In fact the only nations that provide more than 2% of China's inputs-for-export are Japan, Korea and the US.

bilat I2E '08	UK	Germany	France	Italy	NL	Austria	Switz	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Sweden	Brazil	Chile	Russia	S.Africa	India	Indonesia	Australia	China	Japan	Korea	US	Mexico	Canada
UK					4					2	2				13	3			2	4			2						
Germany	5		6	5	7	16	10	14	18	9	6	7	5	3	3	6	4	2	14	11	2	3						4	
France	2			3	2		2	3	3		5	4				2			5	3									
Italy					3		3	3	4	3	4	3		4					6	3									
NL	3	2								2	3		2			2			2										
Austria									3																				
Switz						2																		6					
Poland									4										3										
Czech R								2																					
Denmark																5													
Spain												16																	
Portugal																													
Finland																3			3										
Greece																													
Ireland																													
Sweden										5			4						2										
Brazil																		7											
Chile																													
Russia		2			5			8	6		2		15	5		4													
S.Africa																					2								
India																						2		3					
Indonesia																								3					
Australia																					3	4		2	3	4			
China	2			2	2			5	7	2	3		3			3	6	8	14	12	7	14	6		2	12	3	14	3
Japan									3								2	3		5		14	4	5		8		6	
Korea																			5	2	2	6		4				6	
US	3				3						2				3		9	15	4	9	5	5	5	2		4		49	21
Mexico																			2								3		
Canada																											4	3	
Own & Row	69	76	74	73	66	64	75	42	35	65	62	55	54	75	69	60	60	47	25	31	56	41	71	77	88	57	82	6	65

Figure 17: I2E interdependency matrix, 2008 (% of total intermediate usage).

Notes & Source: See Figure 16.

- The headquarter-versus-factory-economy distinction comes out very clearly in the bilateral I2E data.[12]

The rows of HQ economies are very full as they are key suppliers to many partners, but their columns are very empty. Nations with advanced technology and high-wages (the headquarter economies, especially Japan, Germany and the US) have tended to offshore certain stages of production to nearby low-wage nations (the factory economies). This has created regional supply chains sometimes called Factory Asia, Factory North America and Factory Europe. China does not fit neatly into this two-way categorisation; evidence presented below suggests that China is exporting low-tech industrial intermediates and importing high-tech ones.

3.7.1. Evolution of I2E sourcing patterns: 1995 versus 2008

Changes from 1995 can be seen by comparing Figure 16 with the same matrix for 1995 (Figure 18). The differences are stunning.

- The 1995 matrix is sparser than the 2008 matrix.
- All nations relied less on I2E in 1995 than in 2008.

These facts reflect the 2nd unbundling – especially the rapid growth in North-South I2E trade shown in our intraindustry trade index charts (Figure 1). The increase in Mexico's role in the US supply chains is especially remarkable.

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[12] See Baldwin (2006b) introduced the term 'Factory Asia' and the distinction between headquarter economies and factory economies.

- The rise of China as a source for I2E trade is stunning.

In 1995, which was before China's determined effort to join supply chains (as a means of building their own), no nation sourced more than 2% of its export-inputs from the China; Japan and the US were the only important supplier of intermediates in Asia. China's only significant source of imported intermediates used in exporting was Japan.

In the intervening 13 years, China's fantastic manufacturing growth meant that is now an important supplier of industrial inputs to most nations in the world. On its purchasing side, it sources significant amount from Japan, Korea and the US in 2008.

- Supply-chain trade of the I2E type was much more regional in 1995 everywhere except East Asia.

In 1995 few entries outside of the regional boxes were significant and almost all of those involved the US.

- The rise of trans-Pacific I2E is one of the biggest global changes in I2E since 1995.

In 1995, the only globally important flows across the Pacific involved Japanese intermediates supplied to the US and Canada (mostly auto parts). In 2008, all three North American nations are sourcing heavily from China, Japan and Korea.

bilat I2E '95	UK	Germany	France	Italy	NL	Austria	Switz	Poland	Czech R	Denmark	Spain	Portugal	Finland	Greece	Ireland	Sweden	Brazil	Chile	Russia	S.Africa	India	Indonesia	Australia	China	Japan	Korea	US	Mexico	Canada
UK					3					2	2	3	3		7	3				2									
Germany	4		4	4	7	16	6	4	7	7	4	6	5	3		6				3									
France	2	2		3	2						4	4																	
Italy			2		3						2	3		4															
NL										2						2													
Austria																													
Switz																													
Poland																													
Czech R																													
Denmark																													
Spain												8																	
Portugal																													
Finland																													
Greece																													
Ireland																													
Sweden										4			4																
Brazil																		2											
Chile																													
Russia												2																	
S.Africa																													
India																													
Indonesia																													
Australia																													
China																													
Japan												2										3	3	4		4	2		2
Korea																													
US	3				2					2	5		2	5		2				5				2	3			4	22
Mexico																													
Canada																											2		
Own & Row	80	83	82	82	78	67	83	88	80	75	78	67	70	83	81	74	94	83	##	87	88	92	83	88	92	87	90	96	70

Figure 18: The global I2E trade matrix, 1995.

Notes & Source: See Figure 16.

3.8. Sales and sourcing of I2E trade by nation

Additional insights come from looking at sales and sourcing patterns for I2E by nation normalising these by the nation's own imports and exports rather than global totals. This allows us to see where a nation sources the intermediates it uses to export and where it sells the intermediates that are used in its partners' exports. We start with the four giant manufacturing nations (Figure 19).

The left chart in each panel shows the nation's I2E sourcing pattern – i.e. the share of its exports made up of imported intermediates from the lists partners. For each partner, the shares are shown for 1995 and 2008 to illustrate the evolution of sourcing patterns. Note that the purchase shares are all positive, but they have been plotted as negative numbers to facilitate comparison between sourcing and sales patterns. The right chart in each panel shows the nation's bilateral exports of I2E trade as a share of its total exports. As usual, tiny partners have been removed to improve readability.

The US figures are in the upper left panel of Figure 19. The key facts are:

- The US's buys significant amounts of I2E inputs from handful of suppliers (Mexico, Canada, China and Japan especially).

- On the sales side (right chart), Mexico and Canada are the big destinations; Mexico's role is rising and Canada's is falling.

The share of US I2E exports to Mexico is rising steadily and has reached almost 5% of US exports. Canada role, initially bigger than Mexico's, has declined steadily. While the US sells some intermediates into supply chains in the other G7 nations, these are all fairly small and declining mildly. China is not a significant destination for this type of US export.

On the purchasing side (left chart where the numbers are forced to be negative for plotting convenience), Mexico and Canada again play a large role and both have seen their importance to the US increase over the period. However, the US has a far more diverse range of suppliers of its intermediates than it does of demanders of its intermediates; China's role has soared and now equals that of Mexico. In addition, Japan, Germany and Korea are importer suppliers of intermediates used in US exports. The role of Japan has declined of the period.

The numbers for Germany come next (top right panel).

- Germany is far more broadly involved in international supply chains than either the US or Japan; it buys and sells a significant amount of intermediates to a larger number of nations (mostly in Europe but also the US).

In 2008, almost 40% of German exports were made up of I2E trade. On the purchasing side, Germany also sources broadly, but again mostly from Europe, although both the US and China are important. Overall the imported inputs constitute about 20% of German exports.

The next panel shows the same figures for Japan.

- Japan's overall pattern is quite different from that of the US.

On the sales side (right bar chart), we see that Japan has a much broader range of 'customers' for its intermediate exports. The supply chains of the US, Korea, China and Germany all buy more than 1% of Japan's total exports for use in producing their own exports. On the sourcing side (left panel), Japan buys mostly from Asia economies and Australia, with the role of China and Indonesia increasing significantly. The US is also a major supplier but its role has decline. The rising importance of the natural resource rich nations like Australia and Indonesia is remind us that these supply chain calculations include primary goods.
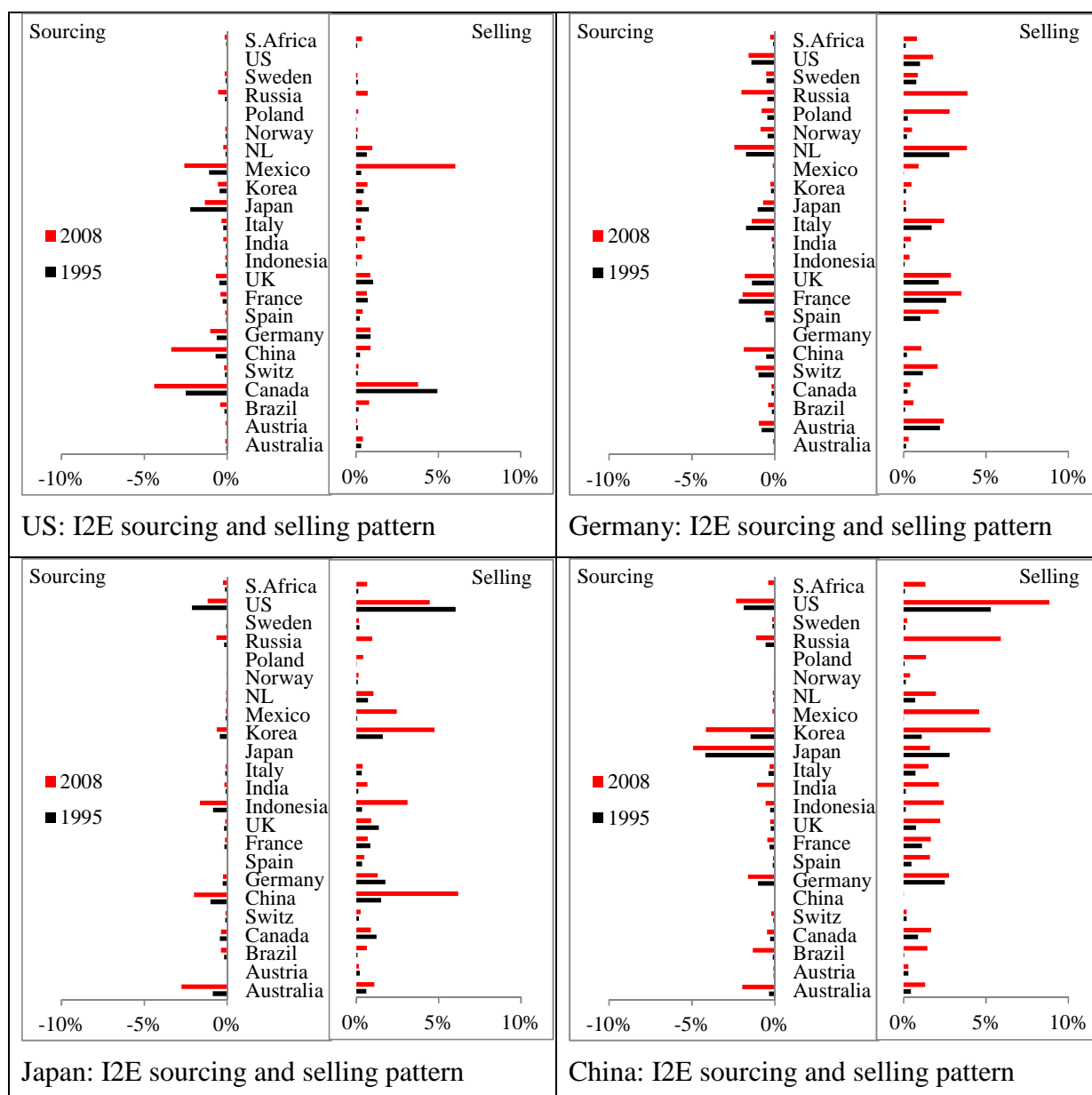
Figure 19: Sourcing and sales patterns, 1995 to 2007, US, Japan, Germany and China
Source: Authors' calculation on OECD IO tables.

The lower right panel shows the facts for China.

- On the sales side, China's pattern resembles Japan's but with a heavier reliance on the US market; on the purchase side, however, its buying pattern is more specialised than the other four giants.

We conjecture that this reflects the links between Chinese manufacturing and advanced-technology companies from the Japan and Korea; hence the strong reliance on these nations for inputs that are used in China's exports.

- To some extent, China resembles a headquarter economy on the sales side but a factory economy on the sourcing side.

This may reflect the nation's comparative advantage in final assembly, which means many of its exporters are really indirect exports from some other nation such as Japan (more on this in Section 5). Finally:

- China has fast growing links with resource abundant countries such as Australia, Brazil and Russia both on the purchasing and selling sides.

3.8.1. Typical factory economies

The distinction between factory and headquarter economies comes out clearly when comparing the same sort of diagram for nations that are known to be closely linked to the industry of one headquarter economy. We choose four of the most obvious examples, Canada, Mexico, Poland and Hungary.
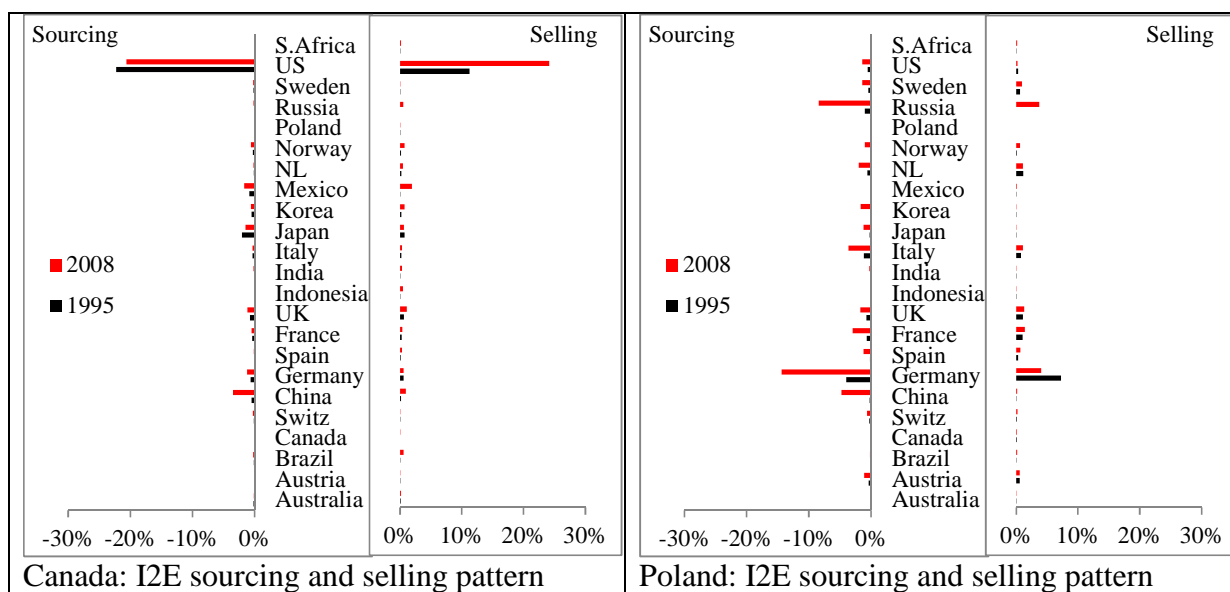
Figure 20: Factory economy sourcing and sales patterns, Canada & Poland.

Source: Authors' calculation on OECD IO tables.

The clearest feature of the charts for Canada and Mexico is their extreme dependence on the US for both sales and sourcing. (Note that the scale is from -40% to +40% rather than -10 to 10 as for Figure 19.) For Mexico the US orientation has been growing rapidly while that of Canada's has been declining on the sourcing side and rising on the selling side.

The charts for Poland and Hungary show a similar dependence on the neighbouring industrial giant, Germany, but the figures are less extreme.

3.8.2. Features of HQ and factory economies

These charts show a pattern. Advanced technology headquarter economies buy and sell I2E intermediates to and from a wide range of partners. Factory economies are heavily dependent on one partner, which is always the nearest advanced technology manufacturing giant (US, Japan and Germany). China is something of an in-between case. On the sales side, it acts like a headquarter economy in that it supplies a broad range of partners. On the sourcing side, however, it sources mainly from the three advanced-technology nations, and Korea.

4. REEXPORTING / REIMPORTING

To dig deeper into the global pattern, we turn next to the a refinement of supply-chain trade.

This refinement is a subset of I2E and it allows us to pick up simple offshoring relationships. The concept – reexporting / reimporting – zooms in on particular partnerships where one nation is sending parts to another and them bringing them back for further processing or consumption. See Figure 21 for an illustration of the concepts.[13]
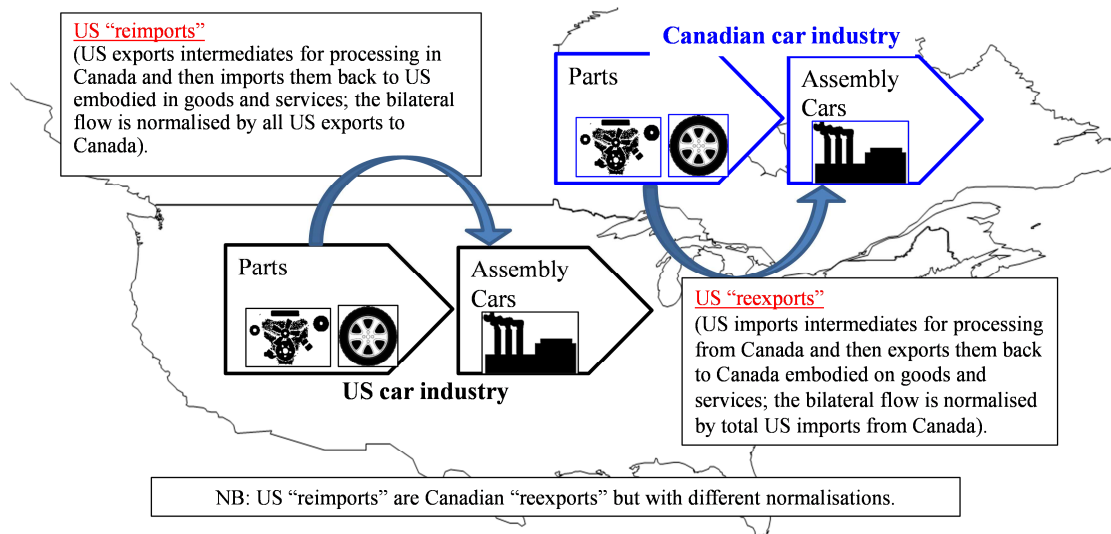
Figure 21: Schematic illustration of reimporting and reexporting supply-chain trade

Reimporting and reexporting is used to capture bilateral supply-chain relationships like one that exists between the US and Mexico. The US firms exports intermediates to Mexico and Mexico exports intermediates to the US. What reimporting captures is the fact that a certain fraction of the value of Mexican exports to the US is made up of US intermediates. In other words, the US intermediates are making a roundtrip to Mexico. We normalise the bilateral flow by the bilateral imports to get the reimporting share.

For example, about 70% of US imports from Mexico consist of US-made intermediates that had previously been exported to Mexico.

4.1. Factory North America

The North American reimporting/reexporting pattern shows the extreme asymmetries that provide the archetype for the headquarter vs factory economy classification.

- US shipments of intermediates to its nearby low-wage neighbour (Mexico) are reimported, but it reexports very little; i.e. US reimporting from Mexico is large but its reexporting to Mexico is small.

Or, to put the same fact in the terminology of offshoring, the US offshores many intermediate production stages to Mexico but reimports the resulting goods either as intermediates for further processing or as final sales. Specifically, the left panel of Figure 22 shows that 65% of US exports to Mexico in 2008 were made up of intermediate goods that were subsequently reimported by the US. The mirror image of this shows up in the Mexico chart (right panel).

- Canada has a similar, although attenuated pattern; 31% of US exports to Canada are reimported; 5% of Canadian exports to the US are reimported.

- The reexporting pattern shows clear evidence for hub-and-spoke network based on the US hub.

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[13] While there is some direct administrative data on this sort of processing trade, it is limited in country coverage and misses a great deal of such processing when it is not organised within a single firm.

Canadian processing for Mexican industry (Canadian reexports) and Mexican processing for Canadian industry (Canadian reimports) make up only 2% and 11% of the bilateral trade.

Moving outside the NorAm region, we see that Mexico does some reimporting from nations beyond the region, especially Korea and Chile (5% and 3% of bilateral trade respectively), and Mexico is an important re-exporter to China, Korea, Germany and Japan. The shares of such trade in Mexico's bilateral trade amount to 27%, 13%, 10% and 10% respectively. Canada, by contrast, does little reimporting or reexporting for non-NorAm nations; the largest is re-exports with China and this accounts for only 3% Canadian exports to China.
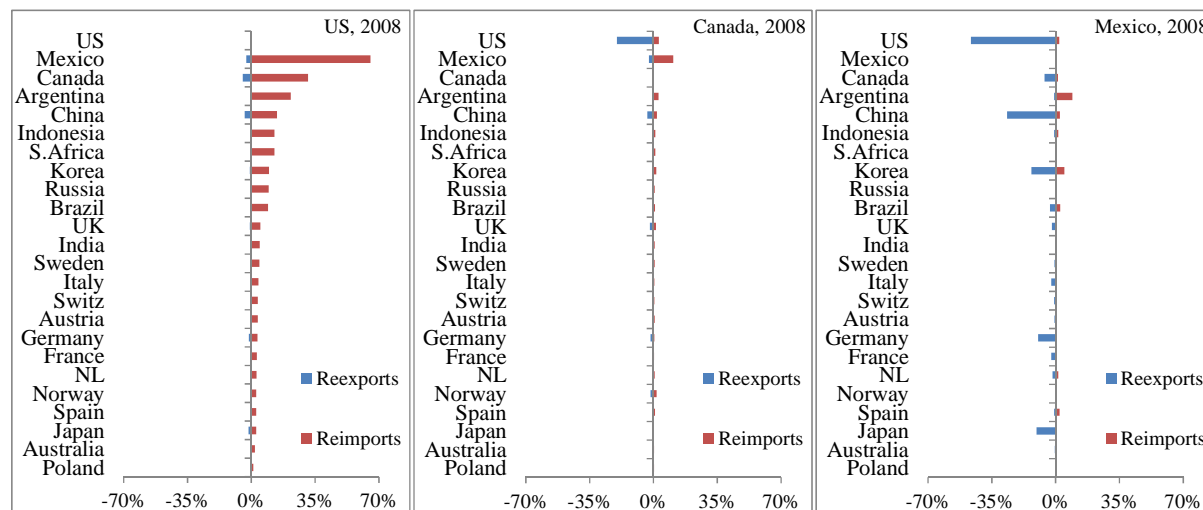
Figure 22: Factory North America: US, Canada and Mexico (reimports and reexports).

Notes: For example, US reimports from Mexico shows the share of the value of US's imports from Mexico that consist of intermediates that originally came from the US; US reexports to Mexico shows the share of US exports to Mexico that consist of intermediates that originally came from Mexico. US reimports from Mexico concern the same flows and Mexico reexports to the US, but the former is normalised by US exports to Mexico and the latter by Mexico exports to the US. Source: Authors' calculation on OECD IO tables.

4.1.1. Evolution: 1995 to 2008

The spectacular evolution of Factory North America can be seen by comparing Figure 22 and Figure 23. As the introduction notes, North-North supply-chain trade was common since the 1960s so little changed for Canada between 1995 and 2008 (the big offshoring boost came with the US-Canada Auto Pact). The radical change came with North-South offshoring and the reimporting/reexporting trade it sparked. In 1995, the US did almost all of its offshoring to Canada and a bit to Mexico (as measured by US reimporting figures).

By 2008, the involvement is Mexico increased enormously as a share of US exports to Mexico but had not increased much with Canada (as a share of US exports). By contrast, the US started reimporting its own intermediates from a much wider range of partners including China and Indonesia. Note that reimports here include the full supply chain so US capital good exports are counted in the reimports if China uses US capital goods to produce, say, mobile-phone exports to the US.

The changes for Mexico are even starker. In 1995, Mexico reexports to the US were a minor story and the reexports to all other partners were non-existent. By 2008, reexports where multiplied many times over as a share of Mexican exports to the US. Mexico also became involved in the supply chains of China, Korea, German and Japan.
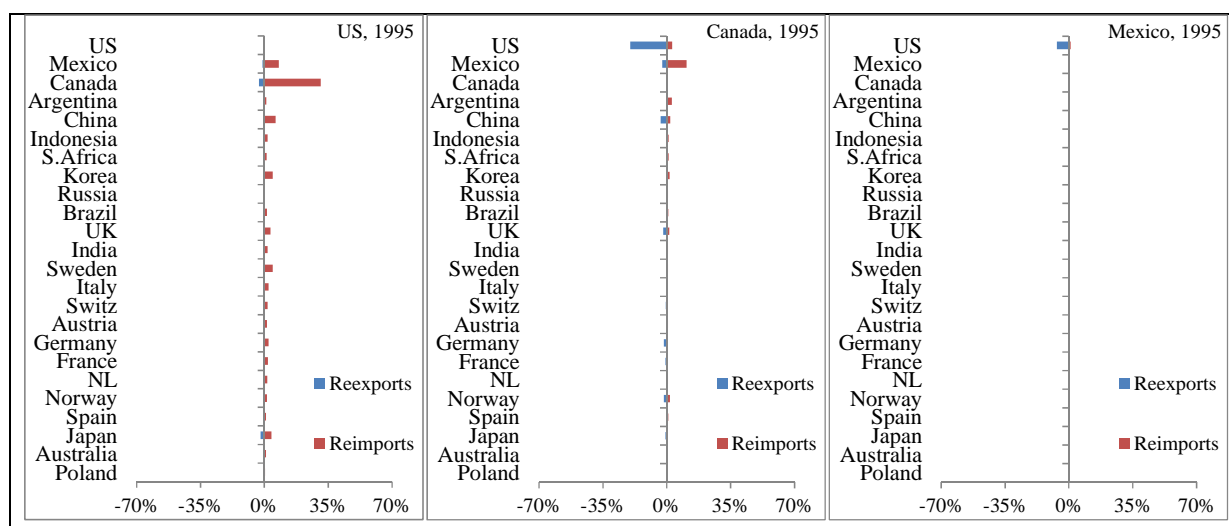
Figure 23: Evolution of reimports and reexports, US and Mexico, 1995 vs 2008.

Source: Authors' calculation on OECD IO tables.

4.2. Factory Europe

A similar pattern can be seen around Germany, although it is more complex given Europe's more elaborate political and economic geography (Figure 24). The top left panel of Figure 24 shows that Germany, like the US, does a great deal of supply-chain trade with its low-wage neighbours. (Note that the scale is -50% to 50% instead of -70% to 70% in the North American charts.) Two differences with Factory North America are worth pointing out.

- Unlike the US, Germany engages in supply-chain trade with other high-wage nations (Austria, Netherlands and Switzerland); we conjecture that proximity matters since each of these nations shares a border with Germany.
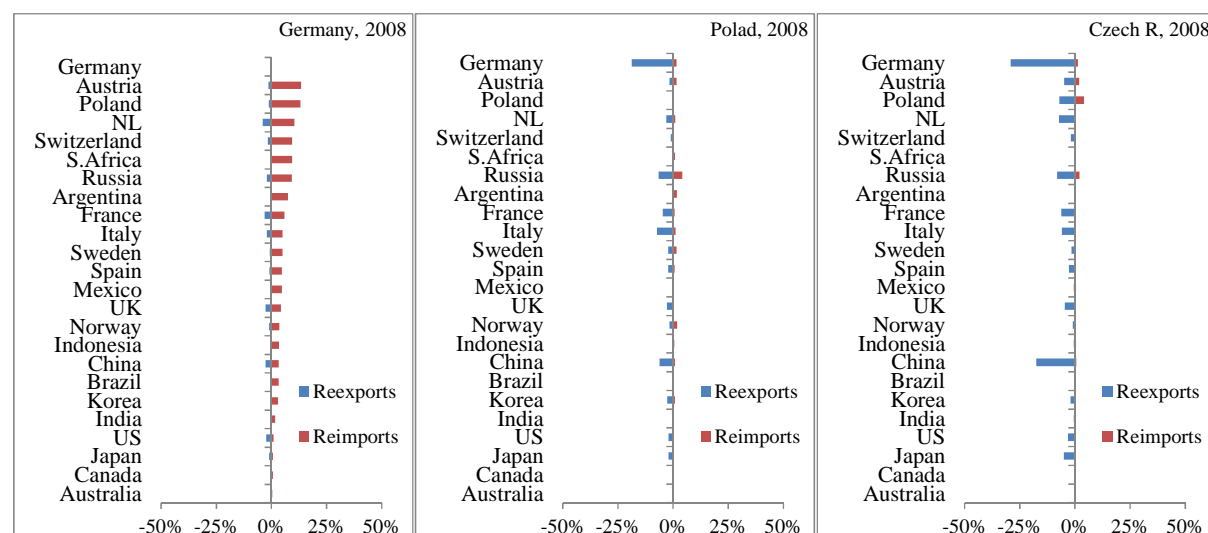
Figure 24: Factory Europe: Germany and low-wage factory economies, 2008.

Source: Authors' calculation on OECD IO tables.

- Germany's reimporting pattern from nearby low-wage nations is far more diverse that of the US. Only about a third of German exports to Hungary are reimported after processing; for the US and Mexico, the figure is almost three-quarters.

Germany's factory-economy partners, such as Poland, share a common dependence on

processing for German industry. For most, 20% or more of the bilateral trade with Germany comprises goods that were imported from Germany, processed and then reexported to Germany (Portugal is the exception at only 11%).

- One striking difference between Factory North America and Factory Europe is the existence of substantial reexports and reimports among the spokes in Germany's hub-and-spoke offshoring system.

In addition to Germany, which is a global manufacturing giant, Europe has three other high-technology nations with large manufacturing sectors: Britain, France and Italy. Figure 25 shows their patterns drawn to the same scale as Germany's.
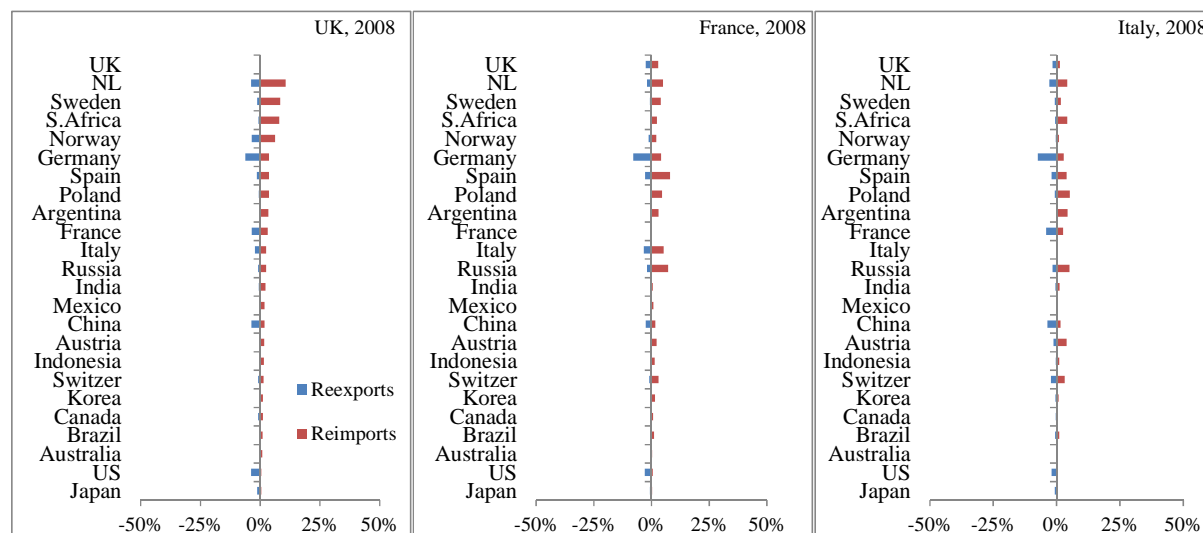
Figure 25: Reexporting/reimporting flows for UK, France and Italy, 2008.
Source: Authors' calculation on OECD IO tables.

We see immediately that these three nations have reimporting and reexporting patterns that clearly place them in the headquarter category – i.e. much more reimporting than reexporting – although Italy is a borderline case. Moreover, although the three reimporting patterns are not as diverse as Germany's, the overall importance of it with at least one partner is similar in magnitude. It is also worth stressing that these three do some processing for Germany, but very little for each other. This suggests that there is a hub-and-spoke arrangement in Europe around Germany and the system includes the other headquarters economies as well as the factory economies (Lejour et al 2012a).

The development of Factory Europe from 1995 to 2008 is more or less in line with developments in Factory North America in terms of magnitude changes, so we don't provide separate numbers for Europe.

4.3. Factory Asia

The situation in Asia is much harder to track. Factory North America is a simple hub-and-spoke system; IE2 is mostly bilateral. Factory Europe is similar but complicated by the proximity of three other high-technology nations hear the hub nation (Germany). Factory Asia is much more like a network and much less like a hub-and-spoke pattern. Processing often involves stops in multiple nations. The most famous example is so-called triangle trade where Japan exports sophisticated components to China for assembly into consumer electronics and onward sale to the US. The bilateral links highlighted in reimporting/reexporting measures will not reveal this.

Another problem is the coverage of the OECD tables is heavily biased towards Europe. Several key supply-chain traders – Thailand, the Philippines, and Malaysia – are not included. To get a handle on the second dimension, we show the intermediate sourcing pattern from the year 2000 JETRO Asian IO table (Figure 26; the 2000 matrix is the latest available; see IDE-JETRO 2006). This has the advantage of including more East Asian nation but the disadvantage of having fewer other nations and of not being standardised with the WIOD data.[14]

The matrix in Figure 26 shows the share of intermediates used by the column nations that are sourced from the row nations. All cells less than 1% have been zeroed to improve readability. As usual, the diagonal shares (own provision of intermediates) are all very large, especially for the large nations, Japan, the US and China. Much of Figure 26 is in line with the findings above – Japan, the US and Korea are major suppliers for all nations in the region. One key point is that the nations excluded from the OECD sample matter for each other but not for the four large manufacturers shown (the US, Japan, Korea, or China). For example, Malaysia supplied 2% of Thailand's and the Philippine's intermediates, but less than 1% for the four economically large nations. This result suggests that the lack of OECD IO tables for Thailand, Malaysia and the Philippines is probably not a major issue for interpreting the supply-chain trade of big nations in the OECD sample. In particular, Indonesia sources less than 1% of its intermediates from Thailand, Malaysia and the Philippines. With this noted, we proceed to analyse Factory Asia using the techniques applied to the North Atlantic regions.

	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Taipei	Korea	Japan	US
Indonesia	90%	1%		1%						
Malaysia		58%	2%	7%	2%			1%		
Philippines		1%	71%							
Singapore		7%	3%	67%	2%		1%			
Thailand		2%	1%	2%	77%					
China		2%		2%	2%	93%	1%	1%		
Taipei		3%	2%	1%	1%	1%	77%			
Korea	1%	2%	3%	2%	1%		2%	87%		
Japan	2%	9%	7%	8%	7%	1%	7%	4%	96%	
US	2%	7%	5%	6%	3%		4%	3%	1%	96%
HK		2%	2%							
RoW	2%	4%	4%	4%	4%	1%	3%	2%		1%

Figure 26: Share of column nation's intermediate inputs from row nations (%)
Source: Baldwin (2006b) adapted by authors.

Returning to the Lopez-Gonzalez data based on OECD IO tables, the reimporting diagram for Japan (left panel of Figure 27), is that of a classical headquarter economies like Germany and the US. In particular, Japan engages in a lot of reimporting but very little reexporting. (Note the scale is -50% to +50% as for Europe; for North America it was +-70%.) The key points are:

- The level of reimporting and reexporting by these three nations is much lower than in North America and for Japan it is much lower than the US or Germany.

This may seem surprising given the view of Asia as having the most extensively internationalised production network. Indeed, these numbers show us that while reimporting

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[14] JETRO perceived the need for WIOD-like efforts decades ago and has produced 5-yearly Asian input-output table back to 1975.

is a good way to capture a simple back-and-forth offshoring relationship, it misses more complex production networks where the parts being processed are not returned immediately to the headquarter economy.

- Judging from the European experience, Korea looks like it is a hybrid between a headquarter economy and a factory economy.

It has large reimporting and reexporting relationships with Japan, China, the US and several nations that are abundant in natural resources.

- Again judging from the European experience, China (right panel of) looks as much like an headquarter economy as, say, Italy.
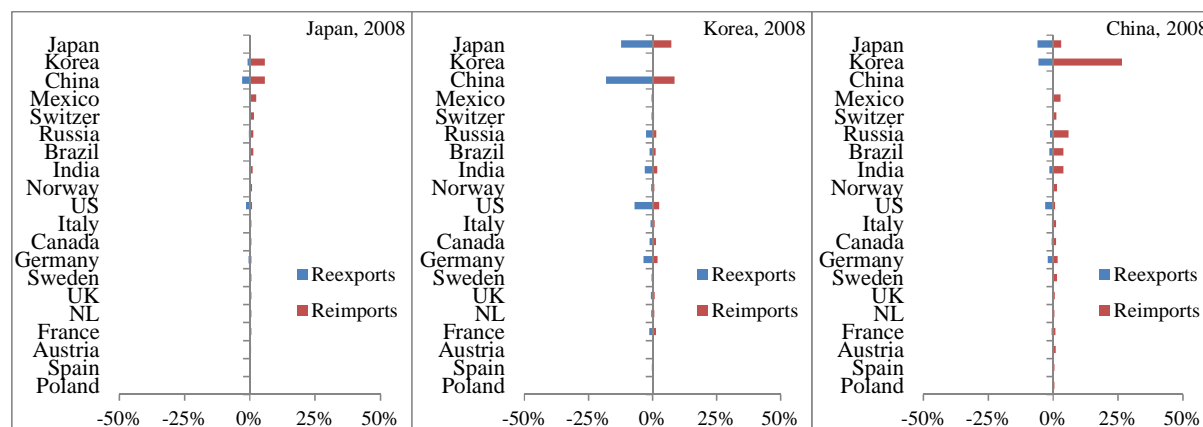
Figure 27: Japan, Korea and China: reimports and reexports by partner
Source: Authors' calculation on OECD IO tables.

The most interesting aspect of this is what we did not find. There is a common perception that China is the assembler of the world, with the famous Ipod case being a leading example (see Linden et al. 2009 and Dedrick et al, 2010). If this perception were true, China's pattern would look like Mexico's. That is, dominated by reexporting relationships with advanced economies and engaging in very little reimporting. Instead we see that most of the bilateral relationships are marked by reimporting relationships.

How can we integrate these facts with the common perception of China as offshore destination par excellence? One plausible explanation is that China is the source for many low-tech intermediate goods that are used in Korea, the US, and Japan. These are embodied in high-tech components which are then sent back to China for final assembly. In this example, the advanced-technology companies are in essence offshoring upstream stages to China as well as assembly. Judged from the European and NorAm perspective, this looks like China is offshoring the middle stages to Korea and Japan.

4.3.1. Triangle trade: From Japan and Korea to China and then to US

To explore this complexity further, we perform an exercise similar to the one that generated data on reimports shown above but we focus on China's exports to the US. The idea here is to see how the intermediate content of China's exports to the US has evolved. The facts are shown in Figure 28. The height of each bar shows the share of China's exports to the US made up of imported intermediates.[15] The bars also show where the imported intermediates are sourced.

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[15] Remember that output equals, by definition, the sum of local value added, local intermediates and imported intermediates.

The dominate feature of the chart are:

- Imported intermediates in China's exports to the US are growing – especially imports from advanced technology nations such as Korea and the G7.

The share of these suppliers' inputs in Chinese exports rose from about 10% to 15% between 1995 and 2008. This provides some support for our conjecture that China is active in supply-chain trade at the very upstream and very downstream ends.
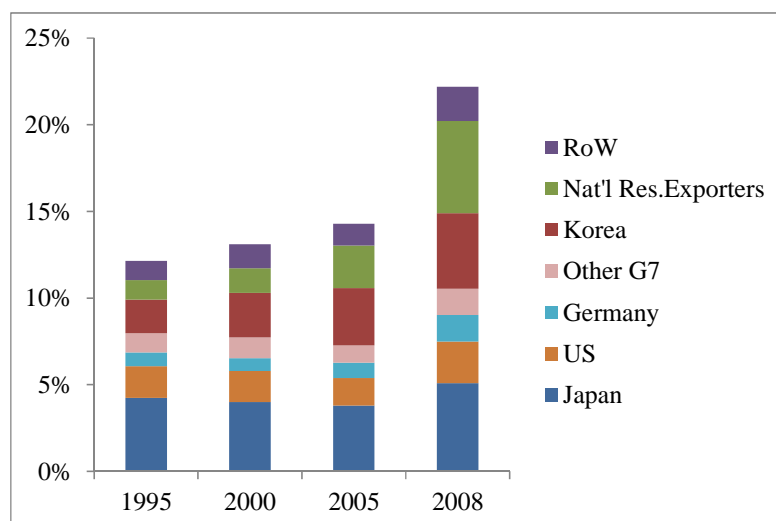
Figure 28: Imported intermediates in China's exports to the US, 1995 to 2008
Source: Authors' calculation on OECD IO tables.

- The biggest increase in imports is from the natural resource exporters in our sample – with the share rising from about 1% to 5%.

Again this provides some indirect evidence for the idea that China's large reimporting activity with the natural resource exporters – e.g. Chile, Argentina, Indonesia and Russia – consists of Chinese exports for manufactured intermediates used in natural resource exploitation (farm and mining equipment, etc.).

5. FOCUS ON CHINA

Given China spectacular rise in the manufacturing league tables and its deep involvement in supply-chain trade globally, it is useful to study China's experience more closely. The basic scene is set when comparing China's soaring share of global manufacturing and its tremendous increase in reexporting and reimporting shown in Figure 25.

The facts show:

- In 1995, China processed goods for Japan and Korea, and did some reimporting from Japan – but all at very low levels.
- By 2008, as noted above, China's had engaged thoroughly in supply-chain trade with a wide range of partners while simultaneously expanding its reexporting relationships with Korea, Japan, Germany and the US.

Figure 25 also sheds light on the phenomenon of so-called South-South trade. We see that China is doing a great deal of reimporting from natural-resource-rich partners like Argentina and Australia. This does not appear to be the sort of simple offshoring relationship we saw between the US and Mexico. We conjecture that China is supplying industrial goods that are

used in the extraction, transportation and refinement of natural resources that China imports from these nations.
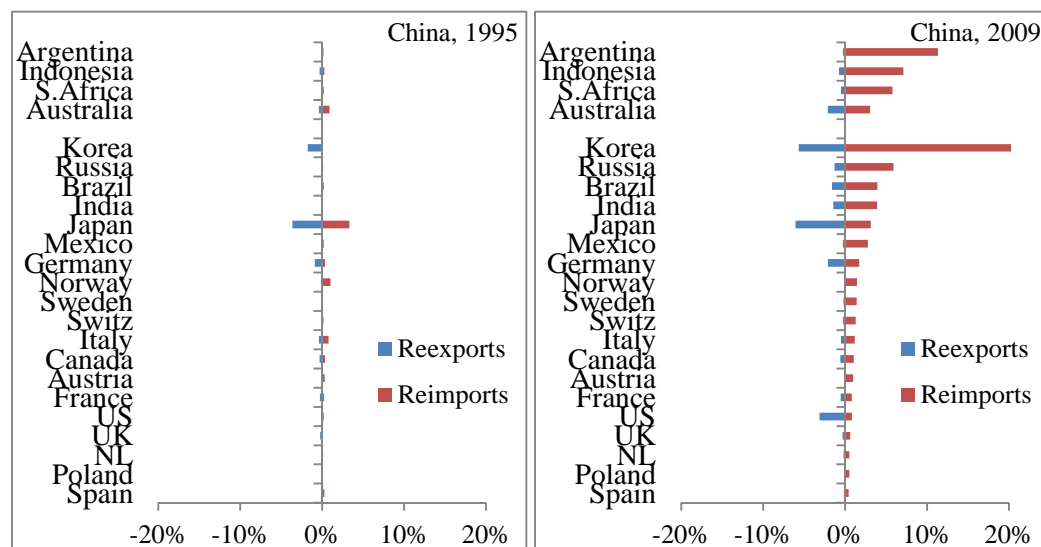
Figure 29: Development of China's reexporting and reimporting, 1995 v 2008.

Source: Authors' calculation on OECD IO tables.

5.1.   Is China moving up the value chain? Cross-sector evidence

It is widely asserted that China is 'moving up the value chain'. There are several ways of interpreting this; we pursue two. The first focuses on cross-sector changes, the second is on within-sector changes concerning intermediates and finals goods. We start with the cross-sector facts.

At the sector level, moving-up the value chain presumably means producing more in high-tech sectors and less in low-tech sectors. Activity in sectors like transportation equipment and electrical and optical equipment should expand; activity in textiles should shrink, at least relatively. To investigate, we use the WIOD data that provides information on 35 sectors – 18 of which are service sectors. To facilitate analysis, we aggregate all service sectors. The facts from WIOD show that between 1995 and 2009:

- China clearly moved up the value chain in terms of gross production, but;
- The change in value added is much more mixed.

The annual growth rates of the two measures are shown by sector in Figure 30. The blue bars show the gross output numbers (which are, by definition, equal to total sectoral sale to all nations including China itself). China's excellent overall growth performance is clear from the chart but especially so in electrical and optical equipment, transport equipment, chemicals and machinery. Below average gross output growth was experienced in sectors like agriculture and related products, non-metallic minerals, leather and footwear, textiles, etc. This is what 'moving up' should look like.

The red bars, however, tell a different story. They show value-added growth (i.e. gross output less intermediates) following a different pattern. Here the fastest growth was in food and related products, basic metals, wood and related products, and mining and quarrying. The below average sectors were agriculture, paper, transport equipment and machinery nec.

Which figures are right? The gross output figures show what Chinese factories are doing; the value added figures show what Chinese workers are doing (and other primary inputs like capital). Traditional economic analysis focuses on value added since this shows the allocation

of scarce resources, but if industrialisation takes places in stages and the first stage is to get production inside the borders, the gross output figures are also important.
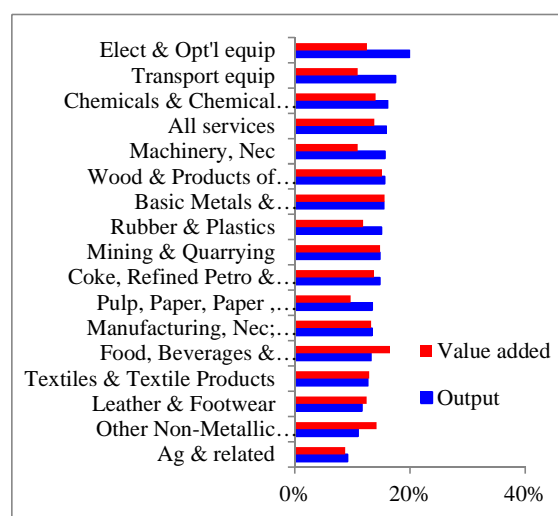
Figure 30: Output and value added growth by sector, China from 1995 to 2009.
Source: www.WIOD.org.

Another line of evidence in the across-sectors strand sheds light on the moving-up hypothesis by comparing China's pattern of intermediates production versus the world's pattern.

Revealed Comparative Production Advantage (RIPA)

While sectoral growth rates are informative, they do not control for the massive change in outsourcing globally – a trend that has affected some sectors much more than others (Figure 6). One way to get around this is to look at intermediates production patterns in China and compare them with the world. The logic here is akin to that of the Revealed Comparative Advantage index, which compares the composition of a nation's exports to the world composition. Instead of exports, however, we focus on the production of intermediates.

This measure – what might be called Revealed Comparative Production Advantage, or RIPA – is shown in in Figure 31 for 1995, along with its components.[16] The blue bars in the left panel show the composition of world intermediates production (i.e. the share of each sector in total world intermediates production); the red bars show the same for China. The difference is what we call RIPA (right panel).

- The dominate feature in 1995 is the massive under production of services in China compared to the world pattern as reflected in the sector's negative RIPA.

China's RIPA for most goods sectors are positive but vary in size. The goods sectors are ordered roughly according to sophistication, ranging from electrical and optimal equipment (this includes electronics) to raw materials like coke, petroleum & nuclear fuel.

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[16] WIOD shows where the output of each sectors is sold and for what use, i.e. as intermediates or final goods. We use the sum of Chinese sales-for-intermediates to all nations, including itself, as Chinese production of intermediates. These are all in gross value terms so there is the usual double counting, but this is purposeful. Our goal is to look at gross production of intermediates in China since we want to track whether China is making more intermediates locally in 2009 as opposed to 1995.
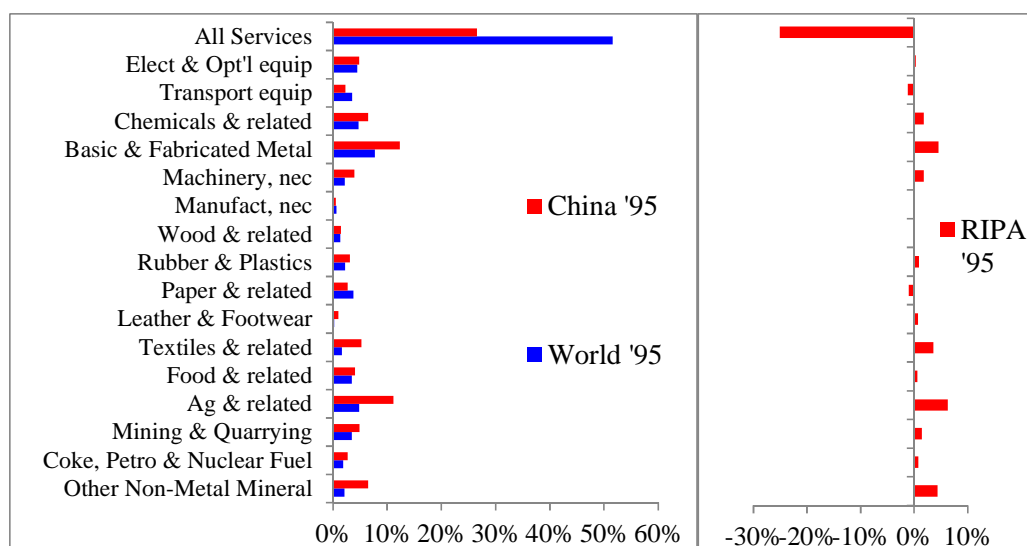
Figure 31: Revealed Intermediates Production Advantage (RIPA), 1995
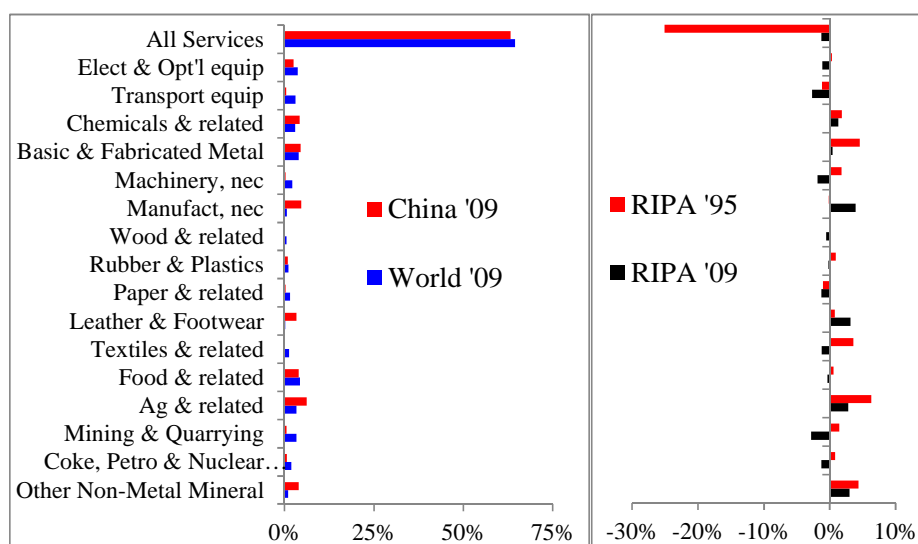
Source: www.WIOD.org

Figure 32: Revealed Intermediates Production Advantage (RIPA), 2009

Source: www.WIOD.org

To gauge the evolution of intermediates production across sector in China versus the world, Figure 32 displays the same numbers for 2009. The left panel shows the two production profiles as before (but for 2009) and the right panel shows RIPA for 1995 (red bars) and 2009 (black bars). The dominant shift between 1995 and 2009 is:

- China's gap in intermediate services disappears.

In 1995, only 27% of Chinese intermediates were in services, while the global figure was 52%; by 2009, the Chinese figure was 63% while the global figure was 64%.

Returning to the up-the-value-chain question, we see in 2009:

- China had a revealed intermediates production advantage (RIPA is positive) in some primary sectors and some light manufacturing sectors.

The former include agriculture and related goods, fuels, and mining; the latter include textiles and related, leather and related, rubber and plastic goods, and manufacturing not elsewhere

classified, nec). China also has a RIPA edge in chemicals, and basic and fabricated metals. To summarise:

- China has a revealed intermediates production dis-advantage (RIPA is negative) in high-tech sectors; and
- A revealed intermediates production advantage (RIPA is positive) in low-tech sectors.

For example, the numbers for transport equipment, and electrical and optical are negative while they are positive for agriculture and related products, leather and related products and manufacturing not elsewhere classified. Table 6 shows the numbers explicitly.[17]

	RIPA '09	RIPA '95	RIPA '09 minus '95
Other Non-Metallic Mineral	3%	4%	-1%
Coke, Refined Petroleum and Nuclear Fuel	-1%	1%	-2%
Mining and Quarrying	-3%	1%	-4%
Agriculture, Hunting, Forestry and Fishing	3%	6%	-4%
Food, Beverages and Tobacco	0%	1%	-1%
Textiles and Textile Products	-1%	4%	-5%
Leather, Leather and Footwear	3%	1%	2%
Pulp, Paper, Paper , Printing and Publishing	-1%	-1%	0%
Rubber and Plastics	0%	1%	-1%
Wood and Products of Wood and Cork	-1%	0%	-1%
Manufacturing, nec; Recycling	4%	0%	4%
Machinery, Nec	-2%	2%	-4%
Basic Metals and Fabricated Metal	0%	5%	-4%
Chemicals and Chemical Products	1%	2%	-1%
Transport Equipment	-3%	-1%	-1%
Electrical and Optical Equipment	-1%	0%	-1%
All Services	-1%	-25%	24%

Table 6: China's RIPA in 1995, 2009 and swings by sector.

Source: www.WIOD.org

The interpretation of these numbers, however, is not straightforward since a low-tech sector like agriculture can use very high-tech intermediates, and some intermediates in high-tech sectors are themselves very low tech. Nevertheless, this finding cast doubts on the notion that China is shifting its intermediates production in a way that makes it more self-sufficient in high-tech sectors. Of course the level of aggregation could be hiding many important developments, but RIPA does not provide any clear evidence of an upward shift in China's value chain.

5.2. Within sector evidence: Substituting local for imported intermediates

Next we turn to intermediate usage. We are looking for evidence that China is replacing imported intermediates with domestically produced ones, especially in high-tech sectors. We start with the composition of China's intermediate usage for all production rather than simply those used for exporting (i.e. I2P rather than I2E).

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[17] This conclusion can be moderated when we consider only goods. The reason for doing so is that the dominate swing in services between 1995 and 2009 is so massively positive that it tends to make all other changes negative. That is, given the way the index is formulated, the distribution of swings in goods must be on average negative by 24 percentage points. The big winners among the goods sectors – i.e. where China's RIPA rose the most – were in manufacturing nec (4 percentage points), and leather and related (2 percentage points). The rest saw China losing ground with the heaviest losses in low-tech industries such as metals, and textiles.
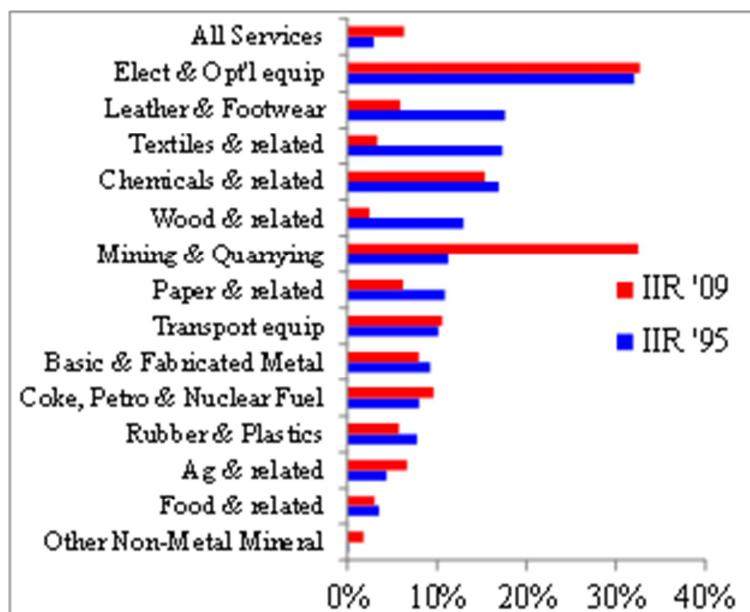
Figure 33: Imported Intermediates Ratio (IIR): China 1995 & 2009.
Source: www.WIOD.org; note: IIR = Chinese imports of intermediates over Chinese usage of intermediates (sourced locally and abroad).

Evidence from the imported intermediates ratio (IIR)

To investigate local versus foreign sourcing of intermediates, we look at China's intermediates import ratio. This is just the value of imported intermediates over the sum of imported and locally sourced intermediates. As Figure 30 shows, in 1995 China sourced less than 20% of its intermediates from abroad in most of the sectors, although for electrical and optical equipment the figure was over 30% (blue bars).

To look for switches from imported to local sources, we also plot the imported-intermediates ratio (IIR) for 2009 (red bars). The notable facts are:

- China saw a very large switch *towards* foreign sourcing in services, and natural resource sectors (mining and quarrying);
- Large switches *away from* foreign sourcing in 'light manufactures' (textiles and clothing, leather and footwear, and Wood and related products).
- China's dependence on imported intermediates did not abate in the higher-tech sectors such as electrical and optical equipment, transport equipment or chemicals.

This is mixed evidence for the moving up hypothesis. There were significant switches to local intermediates (evidence for the hypothesis) but, they occurred most strongly in low-technology manufacturing sectors (leather, textiles, wood, etc.).

5.2.1. China's source of intermediates

At the level of aggregation used above, it is clear that very different goods are being lumped together in the IIR. To get a bit of traction on the sophistication of the intermediates, we add the country of origin dimension. The behind this fine-tuning is that intermediates sourced from advanced technology countries are like to be quite different from those sourced from low-wage nations. The data is displayed in Figure 34.
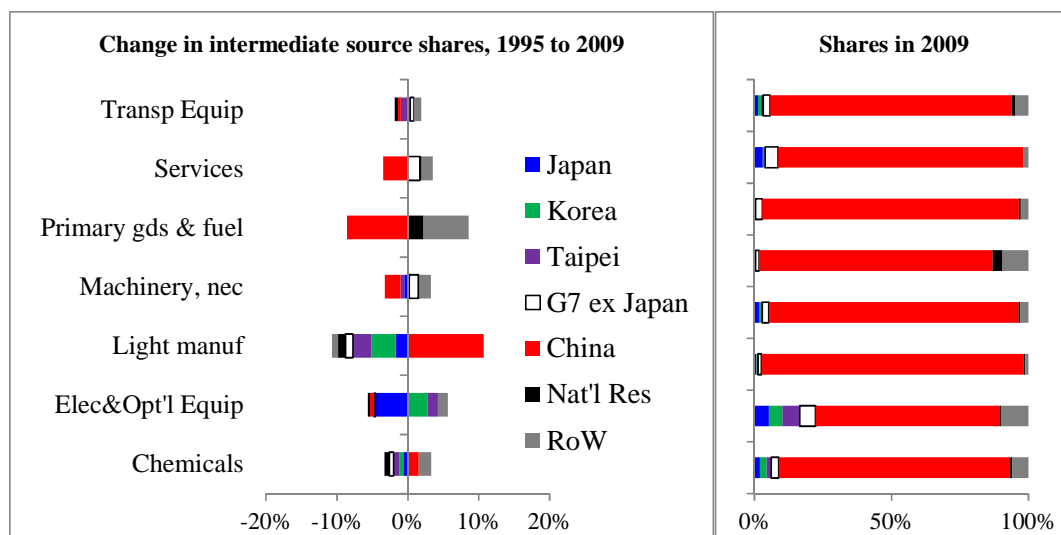
Figure 34: Changing sourcing, China: What and from whom, 2009 vs 1995.

Source: WIOD with authors' calculations. Natural resource exporters are Australia, Canada and Russia.

The WIOT table provides information on 35 sectors, but to facilitate analysis we group them into eight categories of goods, namely: Chemicals, Electrical and Optical Equipment, Light Manufacturing, Machinery not elsewhere classified, Transportation Equipment, Services and natural resources.[18] We distinguish seven sources of intermediates: Japan, Korea, Taipei, the G7 nations (excluding Japan), domestic (i.e. China) sources, natural resource exporters and everyone else (RoW).

The right panel shows the sourcing shares of the seven regions in the eight sectors in 2009. The bars in the left panel show the percentage point changes in China's sourcing shares from each nation in each sector (i.e. a source's share in 2009 in a sector minus its share in 1995). Positive numbers suggest a gain in competitiveness relative to the other producers. When supply share is lost between 1995 and 2009, its bar shows up on the negative side and indicates a loss of competitiveness. What we are looking for is evidence that China's intermediate producers are gaining competitiveness in high-tech sectors. The most striking feature in Figure 34 is:

- There has been a large substitution away from domestic sources and towards imported sources for intermediates in Primary goods & fuels, and Machinery nec.

The gaining foreign sources are mostly RoW for primary goods, and RoW and the G7 for Machinery nec. While it is difficult to evaluate the change in Machinery nec, the switch in primary intermediates is perfectly in line with common perceptions that China is drawing in raw materials at a might pace (raw materials count as intermediates in WIOD).

- The light manufacturing sector is where China's edged has increased the most.

China's gain came mostly at the expense of Japan, Korea, Taipei, and other G7 nations.

- A big shift among foreign suppliers occurred in Electrical and optical equipment.

Intermediate inputs from Japan and other G7 nations fell being replaced by imports from Korea, Taipei and RoW (which includes all of ASEAN). The only other notable shift was in

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[18] Light manufactures comprises textiles and clothing, leather and leather goods, wood and wood products, and paper and pulp; Primary goods and fuels consists of Agriculture, Hunting, Forestry and Fishing, Mining and Quarrying, Food, Beverages and Tobacco, and Coke, Refined Petroleum and Nuclear Fuel.

services.

- Services from advanced-technology nations have substituted for those from China.

Recall that these are services that are inputs into the production of other goods and services, not final services sold to consumers or government bodies.

Changes for Japan and Korea

Apart from primary goods, the big share shifts in Figure 34 involve Korea and Japan. To shed more light on China's role in Factory Asia, we show the Figure 34 calculations for Japan and Korea (Figure 35). Japan's numbers are displayed in the top panel; Korea's in the bottom panel.
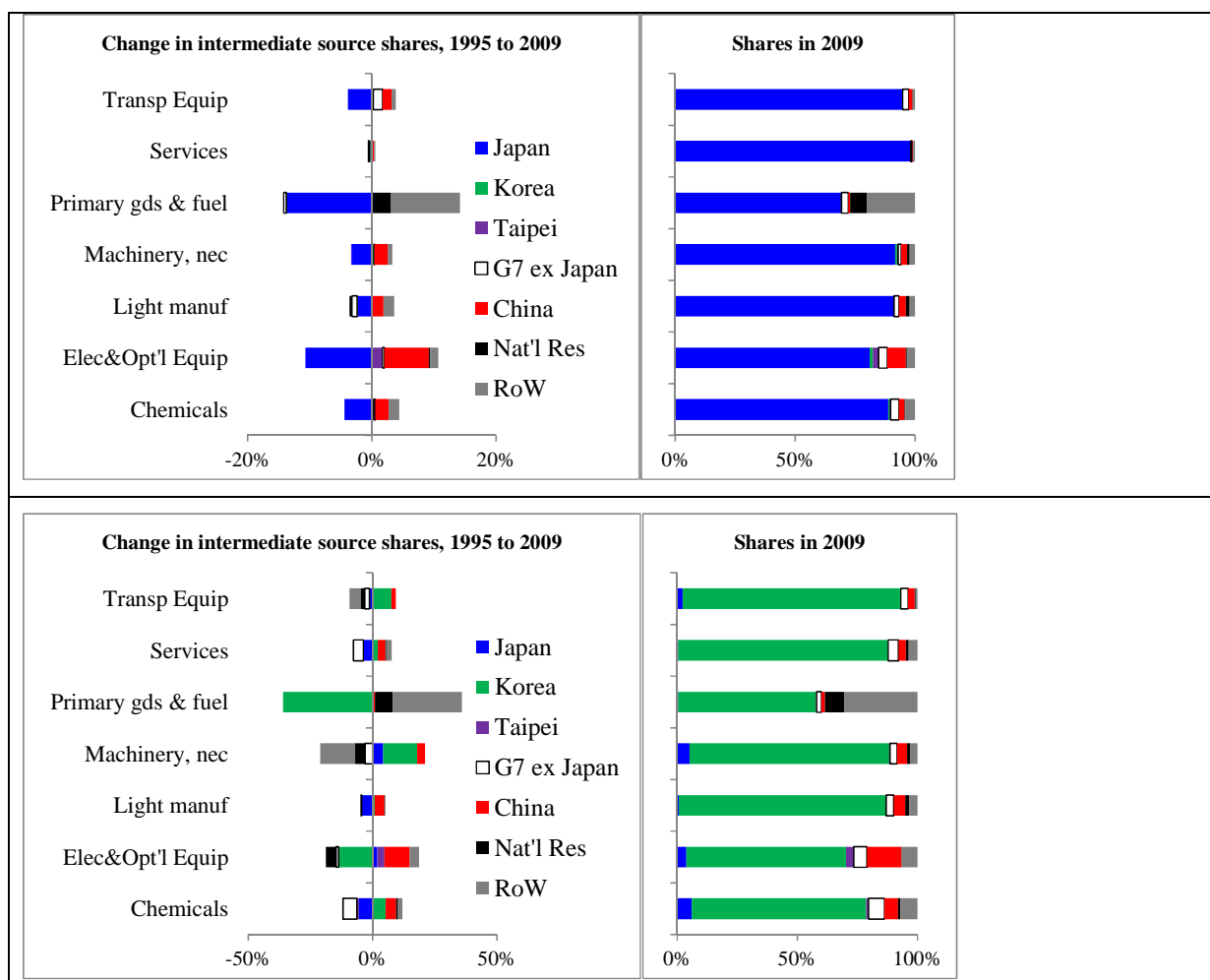

Figure 35: Changing sourcing for Japan (top) and Korea (bottom), 2009 vs 1995.
Source: WIOD with authors' calculations.

Japan's development is one of across the board internationalisation. In every sector except services, sourcing from domestic sources is swapped for greater foreign sourcing. The biggest change is in electrical and optical equipment where China is the biggest gainer. Indeed in most of the sectors, more than half the foreign increase in shares is attributed to China except primary goods and fuels (in transport equipment it is almost half). This is a picture of the famous 'hollowing out' of the Japanese economy. Notice that the 2009 shares of self-sufficiency in intermediates (right panel) are quite similar between Japan and China.

Shifts in Korea's sourcing pattern are more mixed than Japan's and more indicative of 'moving up the value chain' than China's. The big changes are a massive loss of

competitiveness in primary goods (a trend shared with Japan and China), and significant increases in competitiveness in transport equipment and machinery nec. The latter two sectors are typically considered high-tech so the substitution of Korean intermediates for imported intermediates suggests a move up the value chain in these sectors – at least within the very aggregate level of analysis that is possible with WIOD data.

The behaviour of intermediate sourcing in Electrical and optical equipment in the three Northeast Asian nations is noteworthy. Japan and Korea have clearly outsourced parts production to China but not to each other. China, by contrast, has substituted intermediates from Korea and Taipei for Japanese intermediates. Another salient point is the lack of substitution between Japanese and Korean intermediates in those two nations. Despite the massive internationalisation of production that occurred in Asia during this decade and a half, neither Korea nor Japan increased their sourcing from each other in any sector. This can be seen by the lack of blue in the Korean chart (bottom panel of Figure 35) and the lack of green in the Japanese chart.

5.3.   Revealed supply chain advantage (RSCA)

China's participation in international supply chains is widely believed to lie heavily in final assembly rather than production of intermediates for other nations' production processes. As we saw in Section 3.5, the latter part of this assertion is certainly not true as far as other nations are concerned – China is a major supplier of intermediates for nations across the world. Here we look at it from China's perspective. We ask how much of China's exports involve final goods versus intermediate goods.

Our measure – what might be called revealed supply-chain advantage, or RSCA for short – looks at the sector-by-sector share of Chinese exports made up on intermediates and compares this to the world share. The idea behind this, like that of the traditional revealed comparative advantage index (RCA), is that the world intermediates export share provides a benchmark against which to gauge the orientation of China's industry towards intermediates versus final-good exports.

The components of RSCA are show in the left panel of Figure 36. The red bars show the share of Chinese exports in each sector made up of intermediates. For example, Chinese exports in the mining and quarry sector are almost all intermediates, while its exports of food and related products is almost all final goods. The same figures for the world as a whole are shown with the blue bars. China's RSCA index is the difference between the two, with a negative RSCA indicating that China has a disadvantage in the sector when it comes to exporting intermediates versus final goods. To get a perspective on how important the sectors are, the right panel shows China's and the world's export shares for each of the sectors in 2009.

The key point on China's RSCA for 2009 is:

- In 2009, China has a comparative disadvantage in intermediates – and thus a comparative advantage in final goods – in almost all sectors.[19]

This, of course, reflects China's well-known strength as an assembler of final goods.

The middle panel of Figure 36 shows the same numbers for 1995. The key point in comparing 1995 and 2009 is:

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[19] Fuels, chemicals and transport equipment are the exceptions.

- China's comparative advantage as an assembler versus intermediates producer has changed little since 1995 but the magnitudes have fallen (notice the scale in the middle panel starts as -50%).

In other words, China's participation in global supply chains – which has boomed for intermediate and final goods exports – has shifted away from assembly and towards intermediates.
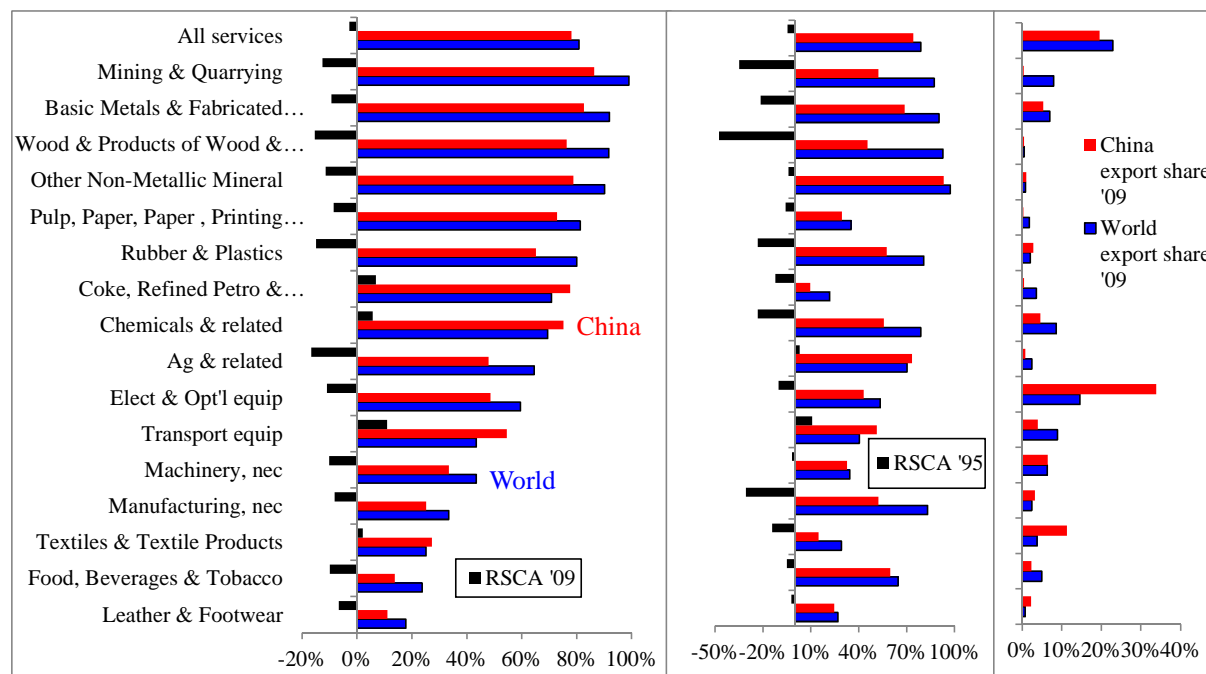

Figure 36: Intermediate export shares and revealed supply-chain advantage (RSCA), China 2009 and 1995.

Source: WIOD with authors' calculations.

For comparison's sake, we show the RSCA for Factory North America, and a pair of nations in Factory Europe in Figure 37. To reduce the clutter and focus on big sectors, we only show the sectors where world exports in the sector are more than 5% of world exports overall.

For Factory North America the RSCAs are shown in the left panel. By definition, a positive RSCA indicates a relative advantage in intermediates and, necessarily, a relative disadvantage in final goods. Thus we can conclude that assembly tends to take place in nations with negative RSCAs and parts production tends to take place in nations with positive RSCAs. The RSCAs for North America shows the familiar pattern in the transportation equipment sector. In transport equipment, the US has a comparative supply-chain advantages in intermediates (and thus an dis-advantage in final autos) while Mexico and Canada have comparative supply-chain dis-advantage in intermediates. This reflects the fact that assembly tends to take place in the in Mexico and Canada while parts production tends to take place in the US. In reality, assembly and parts production take place in all three nations, but the RSCA picks up averages.

A similar pattern is found in the electrical and optical equipment sector; the US is exporting a relative large share of intermediates while Mexico and Canada are exporting a relatively large share of final goods – where relative is compared to the world intermediates export share. In machinery nec, however, it seems that the intermediates are coming from both the US and Canada while the assembly tends to be in Mexico.

In Europe (right panel) we see that in the transportation equipment sector, Poland has the relative edge over Germany in parts, while Germany has the edge in assembly. The pattern is reversed for basic metals and fabricated metal products.
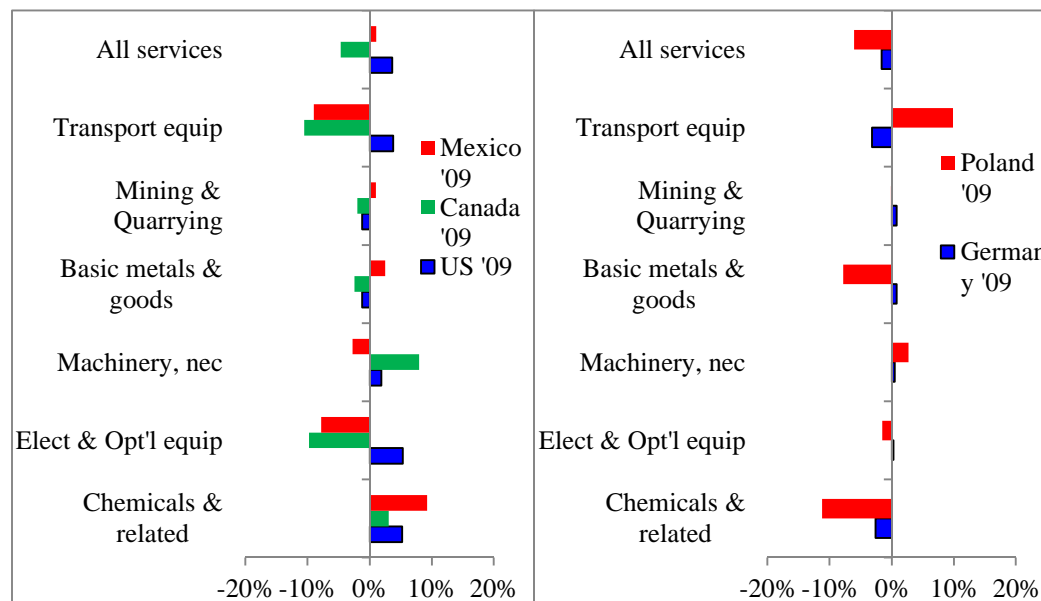

Figure 37: RSCA for US, Canada & Mexico, and Germany & Poland, 2009.
Source: WIOD with authors' calculations.

BOXES

Box 4: Calculation of I2E trade flows

Because I2E trade is computed from the same coefficients that determine an individual country's I2P trade, it is best explained by underlining how these measures relate. If total output and exports were to have the exact same composition, or in other words, if all the products that Mexico sells domestically were also to be sold as exports, then I2P and I2E trade would perfectly proportional. However, as Mexico's domestic sales include non-tradeable services like government services and construction, domestic output and output destined for exports differ. It is this difference that drives the distinction between I2P and i2E. More concretely, because the import content of exports tends to be higher for manufactured products and manufactured products occupy a larger share of the export vector (see Tables 1 and 3), then I2E values will tend to be larger than those of I2P.

Hence I2E trade is a 'computed' measure that requires making the assumption that the technologies used for I2P are the same than those used in producing exports. It is easy to think of counterexamples (e.g. electronics sold to the domestic market are markedly less sophisticated than its exported electronics), but given the lack of country and sector specific data, the 'proportionality' assumption, adopted by all scholars in this field (e.g. it is used in the calculation of I2E trade), is the best we can do. What it means is that these measures are to be interpreted with some degree of caution.

Box 5: Calculating reimports and reexports from IO tables and trade data

Consider Canada's sales and sourcing chart in Figure 21. The left hand bars show Canada's sourcing of intermediates from other nations for goods that get embedded in its exports. This however these are the input shares for Canada's exports to the whole world. While this gives us some idea of how much of US inputs go into goods that Canada exports to the US, using the total export vector misses the fact that

Canada's exports to the US are quite different than its exports to the world. This is where reexporting figures help illuminate supply chains. We combined bilateral trade data (US-Canada) with the two national input-output matrix to get an indication of how much of what Canada's exports to the US is made up of intermediates that Canada bought from the US.

It was earlier highlighted that differences between I2P and I2E trade arise from differences in the domestic output vector and the export vector. In the same way, the difference between reimporting and I2E on the sourcing side is all down to differernces between the composition of a nation's global imports versus its bilateral imports from the concerned partner. An example may help illustrate why this is important. The US' total export vector is likely to be quite full, including such things as natural resources. Its bilateral exports to Mexico, however, focus more on manufacturing products. The measures of re-exports and re-imports will capture differences in the composition of bilateral trade in the calculation of the indicator and hence if the US only exports manufacturing products to Mexico and these have a higher degree of Mexican value added in them then its re-export vector is likely to be larger with Mexico than with the world. See Lopez-Gonzalez (2012) for technical issues and assumption necessary to complete the calculations using IO tables and bilateral trade data.

Box 6: Reimporting and reexporting: An illustrative example
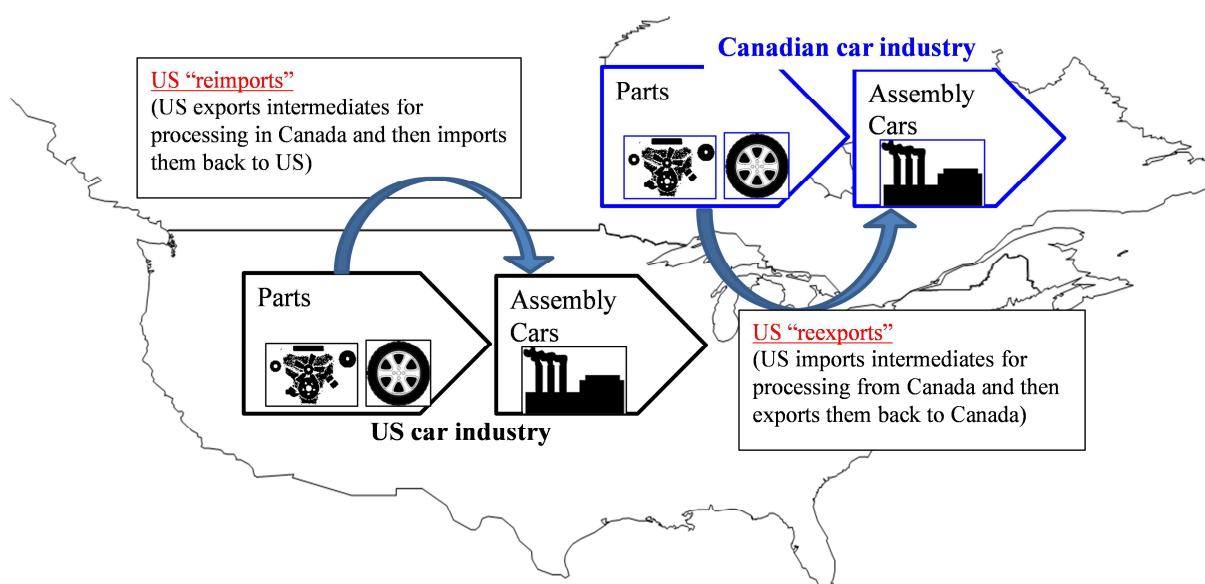
Figure 38: Schematic illustration of reimporting and reexporting supply-chain trade

In Figure 39, the US exports partially processed goods to Canada and then imports them back from Canada after some processing (either final autos or components). Another way to think of this is that the US is the offshore-er in this case, performing some intermediate stage in Canada rather than doing it in the US.

When it comes to US reexports, the US imports partially processed goods from Canada, performs some processing before exporting the result back to Canada. Here the US can be thought of as the offshore-ee and Canada as the offshore-er since some intermediate stage of production is undertaken in the US.

6. SUMMARY AND TESTABLE HYPOTHESES (INCOMPLETE)

This paper presents a portrait of the global pattern of supply-chain trade and how it has changed between 1995 and 2009. We start with basic concepts, distinguishing between

- Importing-to-produce (I2P); and
- Importing-to-export (I2E).

I2P includes intermediate imports used in nontrade sectors like construction and government services. For both I2P and I2E an important distinction is between:

- The 'sales side' (i.e. selling into overseas supply chain); and
- The 'sourcing side' (i.e. buying from overseas supply chains).

Importing-to-export is a recursive concept, which can be full worked out to trace down the ultimate source of all value added in a given export flow. Doing this yields trade measured in a new way:

- Factor content of trade, or 'value added' trade.

6.1. Conditioning facts

- About half of the world's output of goods and services are sold as intermediate inputs.
- World production is not yet very internationalised, i.e. most nations are largely self-sufficient in terms of intermediate inputs.
  - The imported intermediates share of total manufacturing output is only 16%; for all output, it is just 8%.
- The world is more globalised when it comes to manufactured final goods than it is for manufactured intermediates;
  - 44% of manufactured final goods are exported while the figure is only 27% for intermediates.
- Testable hypothesis: The degree of industrial-input self-reliance seems to increase with economic size and distance from the 3 major supply networks – Factory Asia, Factory North America, and Factory Europe.

6.1.1. Sectoral and geographic distribution

- In 2009, the broad composition of I2P trade consists of 52% in manufactures, 28% in services and the balance in natural resources. The shares for services and natural resources both increased between 1995 and 2009.
  - The big manufactures sub-sectors are electrical and optical equipment (13%), basic metals (10%), chemicals (9%), and transport equipment (9%).
- European nations are heavily dependent on German intermediates;
  - Every European nation except Spain, Italy and Russia rely on Germany for at least 2% of their national intermediate purchases.
- The US and China play similarly pivotal roles but with less regional focus; the US is an important supplier in all regions, while China is more focused on Asia.
- Japan's supply-trade pattern is far more regionalised than the US, German and Chinese patterns.
- With Europe, Germany is the hub in a hub-and-spoke pattern; within North America, the US is the hub; the hub and spoke pattern is less clear in East Asia given the important roles of China and Japan.

6.1.2. Between 1995 and 2009

- Supply-chain trade has shifted heavily towards Factory Asia and away from Factory North America and Factory Europe.
- China's role increased enormously on the sales side;
- Germany, Japan and the US all lost global shares on the sales side except with respect to their sales to China.
- Inside Europe, the dominance of Germany faded between 1995 and 2009 both on the sales and sourcing sides.

6.2. Testable hypotheses: I2P versus I2E

- The world pattern of I2E trade is more regionalised and more hub-and-spoke than aggregate trade.
- The global I2E pattern is significantly less regionalised that I2P trade, but the dominance of the US, Germany and China is greater in I2E than I2P; this may reflect the greater involvement of MNCs in export-oriented production.
- Trans-Pacific links are stronger in I2E than I2P trade due to North American purchases from the three large Asian manufacturers (Japan, China and Korea).
- I2P trade is significantly more regionalised than I2E trade.
- I2P trade in industrial goods is more regionalised and more hub-and-spoke, and the dominance of the Giant-4 manufacturers is even greater than aggregate I2P trade.
- The asymmetry between of US, Chinese and Russia I2E on the sales side (their rows) and sourcing side (their columns) is much greater for I2E trade than I2P trade.
- Within Europe the I2E pattern is less centred on Germany (less hub-and-spoke) than is the I2P pattern.
  The asymmetry between of the sales and sourcing patterns for the US and China are much more marked in I2E trade than I2P trade.

6.3. Testable hypotheses: National differences

- The distinction between high-tech 'headquarter economies' and low-wage 'factory economies' can be seen in the differences between a nation's I2E pattern on the sales and source sides.
  - A typical factory economy has few important partners on both sales and source sides;
  - A typical headquarter economy tends to have a diversified geographic pattern of sales but a concentrated pattern of sourcing (typically from nearby low-wage nations).
- Reexporting/reimporting provides a reasonable measure of simple offshoring in Factory North America and Factory Europe, but less so in Factory Asia as the supply-chain trade patterns involve a more complex international production network.

6.4. Testable hypotheses: Industrial goods, services and raw material

The pattern of I2P trade in services is very different than the pattern for industrial goods.

- The world pattern of trade of service inputs is far less regionalised than it is for goods.
- China and Japan are not important players in either the sales or sourcing sides.
- The US is a much more dominant player in I2P services trade than in goods.
- Trans-Atlantic trade in I2P trade in services is more important that I2P trade in industrial goods.
- Intermediate services trade is especially low inside Factory Asia.

- Intermediate services trade inside Factory Europe is at least as important as intermediate goods trade, but the role of Germany is greatly reduced.
- A few small European nations are important providers of intermediate services both inside Europe and to the US.

6.5. Testable hypotheses: China

- The dominate change in China's Revealed Intermediate Production Advantage (RIPA) between 1995 and 2009 has been the elimination of its massive under production of intermediate services.
- Evidence for Chin'a moving up the value chain is mixed:
  - China clearly moved into more sophisticated sectors in terms of gross production, but the change in value added terms is much more mixed.
- China has substituted domestic inputs for imported inputs most rapidly in 'light' manufacturing sectors;
  - The substitution is most marked in leather and related products, textiles and related products, and paper and related products.
  - Little or no substitution has occurred in electrical and optical equipment, transportation equipment, and chemicals.

6.6. The most obvious hypotheses to be tested:

1. Supply-chain trade (both I2P and I2E) are more regionalised than aggregate trade.
2. Supply-chain trade in services is less regionalisation that it is in industrial goods.
3. Supply-chain trade is marked by a more pronounced hub-and-spoke pattern than is aggregate trade.

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6.7. Tables with 0.5% cutoff:

2009 Intermediates	gbr	deu	fra	ita	nld	bel	aut	pol	cze	dnk	fin	swe	irl	esp	prt	grc	tur	rus	bra	ind	idn	aus	twn	chn	jpn	kor	usa	mex	can	RoW
UK																														1%
Germany			1%																					1%						2%
France																														1%
Itlay																														1%
Netherlands		1%																												
Belgium																														
Austria																														
Poland																														
Czech																														
Denmark																														
Finland																														
Sweden																														
Ireland																														
Spain																														
Portugal																														
Greece																														
Turkey																														
Russia																														1%
Brazil																														
India																														
Indonesia																														
Australia																								1%						
Taipei																								1%						
China		1%																							1%	1%	2%			4%
Japan																								1%						2%
Korea																								1%						1%
US																								1%				1%	1%	4%
Mexico																											1%			
Canada																											2%			
RoW	1%	1%	1%	1%	1%												1%							4%	2%	1%	3%			

Figure 10: Global supply chain trade matrix, bilateral flows as share of total, 2009 with 0.5% cut-off

2009 total	GBR	DEU	FRA	ITA	NLD	BEL	AUT	POL	CZE	DNK	FIN	SWE	IRL	ESP	PRT	GRC	TUR	RUS	BRA	IND	IDN	AUS	twn	CHN	JPN	KOR	USA	MEX	CAN	RoW
UK																														
Germany	1%		1%	1%	1%	1%																					1%			1%
France		1%																												1%
Itlay																														1%
Netherlar		1%				1%																								
Belgium																														
Austria																														
Poland																														
Czech																														
Denmark																														
Finland																														
Sweden																														
Ireland																														
Spain																														
Portugal																														
Greece																														
Turkey																														
Russia																														1%
Brazil																														
India																														1%
Indonesia																														
Australia																														
Taipei																														
China		1%																							1%		3%			3%
Japan																								1%			1%			1%
Korea																								1%						1%
US																								1%	1%			1%	1%	2%
Mexico																											1%			
Canada																											2%			
RoW	1%	1%	1%	1%													1%							3%	2%	1%	3%			7%
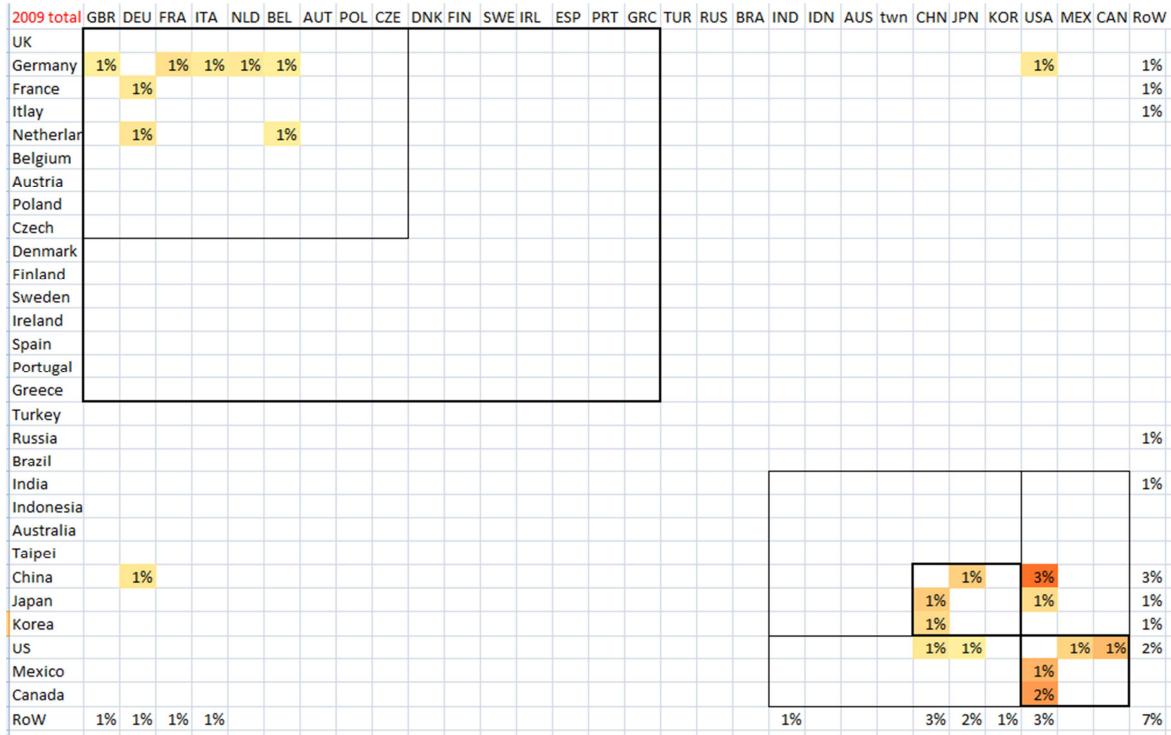
Figure 11: Global total trade matrix, bilateral flows as share of total, 2009 with 0.5% cut-off

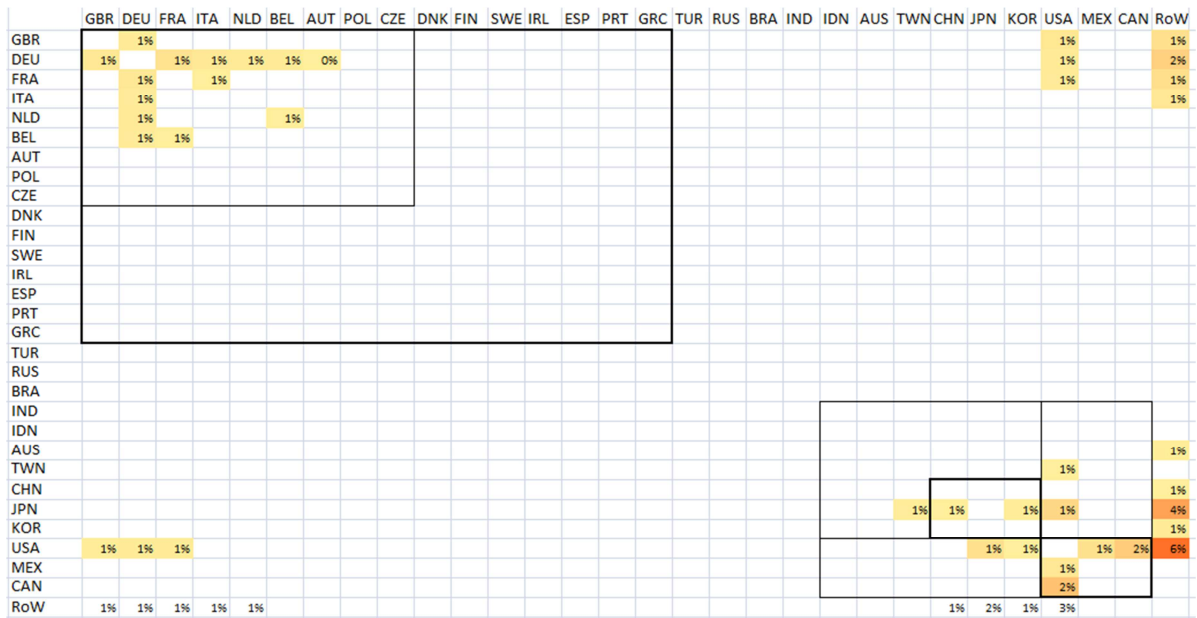|	GBR	DEU	FRA	ITA	NLD	BEL	AUT	POL	CZE	DNK	FIN	SWE	IRL	ESP	PRT	GRC	TUR	RUS	BRA	IND	IDN	AUS	TWN	CHN	JPN	KOR	USA	MEX	CAN	RoW
GBR		1%																									1%			1%
DEU	1%		1%	1%	1%	1%	0%																				1%			2%
FRA		1%		1%																							1%			1%
ITA		1%																												1%
NLD		1%				1%																								
BEL		1%	1%																											
AUT																														
POL																														
CZE																														
DNK																														
FIN																														
SWE																														
IRL																														
ESP																														
PRT																														
GRC																														
TUR																														
RUS																														
BRA																														
IND																														
IDN																														
AUS																														1%
TWN																								1%						
CHN																														1%
JPN																							1%	1%		1%	1%			4%
KOR																														1%
USA	1%	1%	1%																					1%	1%			1%	2%	6%
MEX																											1%			
CAN																											2%			
RoW	1%	1%	1%	1%	1%																			1%	2%	1%	3%			

Figure 39: The global supply-chain trade matrix, bilateral flows as share of global total, 1995

NATURAL RESOURCE ABUNDANT ECONOMIES

Behind the largely manufacturing story herein presented lie important flows of products coming from resource abundant countries. These are much less regional in nature (see Figure App 33) so cannot be grouped accordingly. Here we take 4 obvious examples (Brazil, Chile, Australia and Russia) to highlight their common characteristics which are different to those of factory economies and can be easily mistaken for HQ countries:

- They have rather large re-exports when compared to re-imports
- They all have important links with respect to the 4 giants HQ economies
- They tend to have very low links with each other (although Chile-Brazil is an exception to this)

It is hard to generalise the characteristics of natural resource countries as most of these lie outside the sample that is at our disposal.
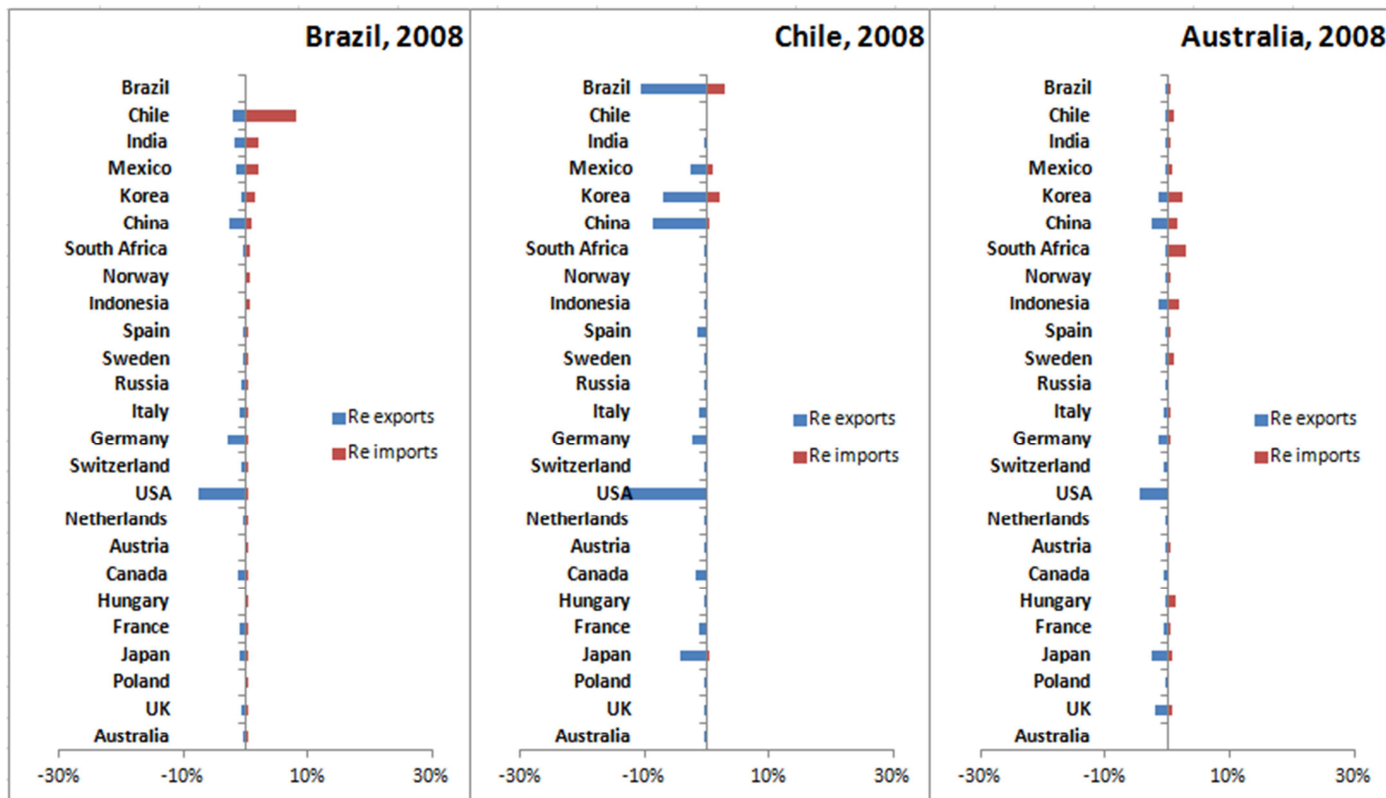
As we shall see, nations with advanced technology and high-wages (the headquarter economies) tended to offshoring certain stages of production to nearby low-wage nations (the factory economies). This has created regional supply chains sometimes called Factory Asia, Factory North America and Factory Europe. [20]

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[20] See Baldwin (2006b) introduced the term 'Factory Asia' and the distinction between headquarter economies and factory economies.