International supply chains and tariff cuts:

Evidence from Factory Asia

Lorenzo Rotunno*

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Abstract

Governments in developing countries have substantially reduced import tariffs during the last three decades. At the same time, some of these countries have gained a major role within global supply chains. In this paper, I examine how the rise of production sharing across countries shapes incentives to use protectionist trade policy. As sectors integrate into domestic and international supply chains, they benefit from access to cheaper inputs and thus lobby for lower tariffs on these products. I find empirical evidence corroborating this idea in seven Asian countries at the forefront of the so-called 'Factory Asia' supply chain. Tariff cuts are indeed significantly larger as imports embed a larger share of re-imported value added that goes back home through the supply chain. Tariffs decrease also with the importance of 'back-and-forth' trade in intermediates, a salient feature of global supply chains. Results support the view of governments acting to maximise local value added within the supply chain. Greater offshoring can tilt trade preferences of domestic producers away from protectionist stances.

Keywords: Trade preferences, offshoring, tariff liberalisation.
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*Post-doctoral Research Fellow, Nuffield College and Blavatnik School of Government, University of Oxford. Merton Street 10, Oxford OX1 4JJ, United Kingdom. Phone: +44 1865614347. Email: lorenzo.rotunno@bsg.ox.ac.uk

1 Introduction

Production unbundling, or the fragmentation of supply chains across borders, has profoundly shaped international commerce (Baldwin, 2012). Stages of production that were previously bundled together have been progressively offshored abroad to exploit the vast wage differences between advanced and developing nations. The emergence of cross-national supply chains has important implications for trade flows (Johnson and Noguera, 2012; Bems et al., 2011), labour markets (Amador and Cabral, 2015; Grossman and Rossi-Hansberg, 2008; Hummels et al., 2014) and gains from trade (Caliendo and Parro, 2014). Nonetheless, little attention has been paid to the effects on the governments' incentives to use protectionist trade policies.

In this paper, I empirically examine the role of international production sharing in explaining changes in import tariffs across sectors and, more importantly, over time. In doing so, I focus on seven East Asian countries that form the so-called "Factory Asia", an area at the forefront of production sharing. Highly connected supply chains in the region developed especially in the 90's (Ando and Kimura, 2005). To see this, Figure 1 plots the evolution of the share of foreign regional value-added (VA for short) in total output, which aggregates the "VS share" measure of Koopman et al. (2014) - e.g. the share of value-added originated in East Asia and embodied in Japanese output. Anticipating what will be discussed more fully in the next sections, this measure is one metric of production sharing. Its value would be zero in a "first unbundling" world (Baldwin, 2012) where production can occur only within the country's borders and increases with trade in intermediates that allows firms to 'employ' factors of production from abroad. The foreign VA share increases in all Factory Asia countries except Indonesia between 1990 and 2005. It doubles in China, going from 10 to 20%, while it jumps from 25 to 45% in Malaysia.

During roughly the same period, the region went also through a major reduction in import tariffs. Figure 2 plots the evolution of applied MFN (Most-Favoured-Nation) tariffs over the last 20 years by major country groups. While tariffs went down worldwide, one of biggest drops occurred in Factory Asia countries, going from 28% in 1994 down to around 10% at the end of the period. Only (some) countries in Latin America went through a similar shift towards lower tariffs. Importantly, governments did most of this tariff cutting unilaterally (Baldwin, 2010). Asian and other developing countries, if members of the GATT/WTO, were not required to reduce significantly their import tariffs - rich countries were the major actors at the multilateral level, as shown by their low MFN tariffs. Some countries of Factory Asia formed the ASEAN Free Trade Area (AFTA) in the mid '90s and this could have triggered liberalisation also of the multilateral (MFN) tariffs. Yet, unilateral decision-making by governments in East Asia outside reciprocal bargains is arguably the main driver of the drop in their MFN tariffs (Vézina, 2014).

The objective of this paper is to assess the relationship between these two trends - the rise of Factory Asia and unilateral tariff cuts. Baldwin (2010) summarizes different theoretical mechanisms that can rationalise a negative effect of greater production unbundling on import tariffs across sectors and over time. These theories turns on the concept of effective rate of protection - the fact that the rate of protection of one stage of production depends upon the difference between the tariffs on the stage's output and on its inputs. This means that a higher tariff on 'upstream' sectors makes inputs more expensive and hence depresses production and profits in 'downstream' industries. In a setting where the government places greater weight on domestic profits (because it accommodates demands from special interest groups Grossman and Helpman, 1994) or value added (as in a "development state" model Johnson, 1982) than social welfare, import tariffs are more politically costly in sectors that provide inputs to the rest of the economy and hence are more exposed to production unbundling. Over time, advances in information and communication (ICT - e.g. computers, faxes, the worldwide web) have loosened coordination constraints and made feasible to control stages of production at distance. As firms offshored part of their production processes, trade in intermediates and parts and components became more important, creating political demand for lower tariffs in sectors more exposed to this supply chain trade.

The different theories imply a common prediction: tariff protection should fall with the importance of production sharing, both across sectors, and, more importantly, within sectors over time. In this paper, I test for this proposition and relate import tariffs with measures of trade in value-added that are consistent with a supply-chain view of trade (Koopman et al., 2014) and that are relevant to the tariff setting problem of the government. Results clearly show an important role of international supply chains in explaining unilateral tariff liberalisation in East Asia. Tariffs are significantly lower in sectors where imports embed more domestic value added that is re-imported back home. This measure captures key aspects of supply chain trade (it would not exist without traded intermediates Koopman et al., 2014; Johnson and Noguera, 2012) and has a direct link to the tariff setting problem faced by the government. I find that the share of foreign value added in production (VS share) is associated with increasing protection over time, although the relationship does not seem to be robust across different specifications. Overall, the empirical findings accord well with the "development state" model of Johnson (1982), where governments use trade policy to maximise local value-added.

My findings complement the analysis of Vézina (2014), who finds evidence for "race-to-the-bottom" tariff cutting in East Asia - i.e. the idea that governments in Factory Asia cut their tariffs to attract Japanese multinationals. His results are consistent with a view of the government as value-added (or employment) 'maximizer', as FDIs are meant to foster local jobs and hence value added. My paper does not explore spatial competition in tariff setting but broadens the scope of the analysis as it focuses on value-added that travels through flows of intermediate goods - which could involve any type of corporate relationship between the supplying sector and the buying one.

The paper also contributes to previous work on the role of supply chains in shaping trade policy and relying essentially on the effective rate of protection concept. Gawande et al. (2011) empirically explore different explanations for the lack of protectionist response following the Great Trade Collapse in 2008-2009 and find that higher dis-integration of supply chains as measured by the Vertical Specialisation (VS) measure (Hummels et al., 2001) deters governments from imposing protectionist measures. Using a refined measure of foreign value added created along the supply chain, I find that vertical specialisation has a rather positive (but weak) effect on import tariffs, while other value-added components that are directly related to sectoral imports (and hence protectionist rents) have a stronger negative impact.

Using a conceptually similar framework, Gawande et al. (2012) introduce domestic input-output linkages in a PFS model where downstream industries lobby for lower tariffs on domestic inputs. They find evidence for a significant role of those linkages in explaining the structure of protection across sectors and the trade preferences of governments. I rely on their theoretical framework and add cross-border input-output linkages together with standard terms-of-trade motives for trade protection (see Broda et al., 2008). I further extend their empirical analysis and find evidence for an important role of the value-added content of intermediates trade in explaining the evolution of tariff protection over time.

My empirical analysis contributes to the vast literature on the empirics of endogenous trade policy models, which nevertheless relies mainly on estimates across sectors and countries (e.g. Maggi and Goldberg, 1999; Gawande and Krishna, 2008 for a review). By exploiting variation within sectors and over time in the importance of supply chains, I provide an empirically important factor that speaks to the "liberalisation paradox" (Baldwin and Baldwin, 1996) - i.e. the fact that governments remove the same tariffs that they decided to impose beforehand. Differential changes in production unbundling across sectors over time (e.g. due to different exposure to and use of ICT) shifts trade preferences of special interest groups - increasing interests in lower tariffs on upstream sectors - and hence tilt the tariff equilibrium towards unilateral liberalisation.

By estimating the relationship between tariffs and value-added trade, I contribute also to previous work that has analysed the effect of transport and man-made trade costs on global supply chains. Yi (2003) shows that even small reduction in trade costs can have large trade effects in a model with vertical specialisation. Bridgman (2012) simulates a trade model with vertical specialisation and finds that falling tariffs have a larger effect on intermediates trade than falling transport costs. In this paper, I look at the other direction of causality, going from production unbundling across borders to trade policy. In doing so, I build on Baldwin (2012) and the evidence in Basco and Mestieri (2013) showing that advances in ICT (rather than falling trade costs) are the main driver of the surge of international supply chains.

In this paper, I draw extensively from recent methodological innovations in understanding trade flows in value-added (Johnson and Noguera, 2012; Timmer et al., 2014). Koopman et al. (2014); Wang et al. (2013) propose a full decomposition of gross bilateral trade flows in their value-added components in terms of their origin (domestic or foreign) and the type of the underlying trade flows trade (in intermediates or final goods). My paper is the first, I believe, to empirically assess the relationship between tariffs and some of these value-added measures.

The rest of the paper is organised as follows. Section 2 introduces the empirical strategy, the data used in the analysis, and provides some descriptive evidence. Section 3 presents the results. Section 4 concludes.

2 Empirical Strategy and Data

The objective of the empirical analysis is to assess the importance of value-added trade components in explaining variation in import tariffs. To this end, I regress the applied MFN tariff rate on VA terms in different version of the following general regression model:

$$(1) \quad T_{i,c,t} = \beta_1 VA_{j,c,t} + \beta_2 X_{i,j,c,t} + FE_{j,c,t} + \varepsilon_{i,c,t}$$

Subscript i denotes a product (an HS 6-digit product category), c identifies the importing country (one of the seven countries in Factory Asia), j gives the sector and t the time period. The dependent variable T gives the ad-valorem MFN tariff at the HS 6-digit product category - the most detailed level that is internationally comparable. The VA term collects one (or more) value-added component of trade flows that reflect the development of international supply chains and are expected to affect tariff protection. The matrix X includes other product- and industry-level variables that previous theoretical and empirical work has identified as determinants of trade policy. Finally, FE is a combination of dummies varying depending on what variation of the data identifies the effect of interest - across sectors or within sectors over time -; while ε is the error term. I focus on the results of the regression model in (1) pooling all seven Asian countries together since I am interested in the average effect of production unbundling on tariffs. In robustness checks, I nonetheless allow the coefficients of interest to vary across countries to reveal any interesting heterogeneity.

The value-added components in the VA term should be relevant to the trade policy choice of the government and, at the same time, correlate with the fragmentation of production chains across borders. To characterise the government's policy choice, I follow the standard approach to endogenous trade policy (Grossman and Helpman, 1994). In choosing tariffs, governments balance social welfare against contributions from special interest groups, import-competing firms in particular. The equilibrium tariffs are chosen in excess of the social-welfare level because governments share the rents generated by the higher tariffs with organised lobbying groups - while consumers, who lose from the higher tariffs, are unorganised. The approach predicts that tariffs increase with the inverse import penetration ratio of the sector (the ratio of output to imports) as governments face the trade-off between social welfare and political contributions from import-competing sectors. A higher output means more rents from protection of the domestic industry (and more profits to the owners of the factor specific to the sector in a Protection for Sale framework Grossman and Helpman, 1994), whereas more imports imply that the same tariff creates more distortions and hence deadweight losses.

In a world where trade in intermediates is a crucial part of trade flows, imports are often made of parts and components that were initially produced domestically. Going through all the different rounds of intermediates flows across sectors and countries, one can trace the origin of value added embedded in gross trade flows (Johnson and Noguera, 2012; Timmer et al., 2014). Applying this approach, Wang et al. (2013) have recently decomposed bilateral gross trade flows in different value-added components. Using their matrix algebra, the value added that is 're-imported' back in country d through gross imports from country o is (see Wang et al., 2013 for details):

$$(2) \quad IVA^{od} = \left(V^{d}B^{do}\right)' \times Y^{od} + \left(V^{d}B^{do}\right)' \times \left(A^{od}L^{dd}Y^{dd}\right) + \left(V^{d}B^{do}\right)' \times \left(A^{od}L^{dd}E^{d}\right)$$

The term IVA is a $J \times 1$ vector, where J is the number of industries and the element $iva_{j,od}$ gives value added generated in d and embedded in gross imports of j from o. The first term of the right of equation (2) measures d's value added (collected in the gross value-added factor

V) that goes through o in net flows of intermediates (the B matrix[1]) and goes back to d through country o's exports of final goods. The second term traces value added that re-enters d as embodied in intermediates exports of o (A^{od}) that are then used in the production of final goods in o ($L^{dd}Y^{dd}$)[2]. The third and final term identifies re-imported value added by d embedded in exports of intermediates by o that are then processed into gross exports of d (E^d). This value added term is part of the double counting in gross trade statistics that naturally arises with trade in intermediate inputs and that is an endemic feature of production sharing. Specifically, it is embedded in d's gross exports to the world, which includes the 'origin' country o. Re-imported value added increases, *ceteris paribus*, with trade in intermediates and hence with the unbundling of production across borders. Intuitively, in absence of net trade in intermediates between d and o (the B^{do} matrix being null), there would be no re-imports of value added[3].

This measure has also bearing on the tariff choice. A government that attaches particular weight on industrial value added (perhaps in addition to industrial profits as in the PFS model) would find it optimal to impose lower tariff on imports that carry with them more domestically produced value added. Baldwin (2010) postulates this type of government preferences, which are consistent with a bias for industrialisation *per se* and are relevant to the case of many governments in East Asia (Johnson, 1982). I thus expect import tariffs to decrease with re-imported value added, given gross imports (which also attenuate protectionist incentives because of the deadweight losses associated with tariffs). In the empirics, I compute IVA for each country-pair relationship between the seven Factory Asia countries and then add the industry-level element iva across origin countries. Dividing the resulting sum by total imports in the sector ($m_{j,d}$), I obtain the share of re-imported value added in total imports:

$$(3) \quad ivash_{j,d} = \frac{\sum_{o \neq d} iva_{j,od}}{m_{j,d}}$$

The $ivash$ variable is predicted to enter with a negative coefficient the tariff regression (1).

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[1] B^{do} is the $J \times J$ block matrix extracted from the $CJ \times CJ$ international Leontief inverse B (C being the number of countries in the global input-output system), which estimates the flow of intermediates from a supplying country-sectors to buying country-sector after taking into account all the gross flows of intermediate - $B = (I - A)^{-1}$, where I is the identity matrix and A is the $CJ \times CJ$ matrix of direct intermediate input coefficient (per dollar of gross output).

[2] A^{od} is the $J \times J$ block matrix from the A matrix of international direct input coefficients. L is defined as the local Leontief inverse - $L = (I - A)^{-1}$.

[3] In a global input-output system, two countries can be linked in an input-output sense even without trading intermediates. To see this, note that A^{do} being a null matrix does not necessarily imply that B^{do} is null.

Following the same logic, the government should grant less protection to a sector where gross output contains more foreign imported value added - holding the positive relationship with total gross output because of the usual rent extraction motives. The concept of foreign content of production is closely linked to that of the import content in a country's exports, which is the vertical specialisation (VS) measure initially proposed by Hummels et al. (2001). Koopman et al. (2014) generalise the idea to a setting with unrestricted intermediate goods trade and provide the "VS share" measure:

$$(4) \quad VSshare_d = \sum_{o \neq d} V^o B^{od}$$

Each element of the $J \times 1$ $VSshare$ vector measure foreign value added used in sector j's production. Since it is expressed as a share, the measure can be applied to any output vector[4]. Figure 1 plots the aggregate of this measure for each country. It clearly increases with the importance of the international supply network as measured by the terms in the Leontief Inverse B. Unlike the re-imported value added share ($ivash$), however, it does depend on the imports of a specific sector - and hence on the related tariff. The foreign value added can be generated in any sector, enter the country through different goods and be used in the production of industry j. Despite this rather weak link with good-specific tariffs, I add the variable to the VA set in equation (1) as an important measure of vertical specialisation.

The main empirical objective is to assess if and how the evolution of international supply chains in Factory Asia contributes to explain variation in import tariffs over time. To this end, I exploit variation over time within countries and sectors by adding industry-country dummies in the FE term in (1). I also control for country-level and time-varying determinants of tariffs (e.g. changes in government that shifts ideological positions, incentives to raise tariff revenues) by including country-year dummies. While the focus is on variation over time, the structure of input-output linkages should be relevant also to the distribution of tariff protection at any given point in time. I hence estimate also a 'pooled' version of (1), expecting the effect of the VA variables on tariffs to go in the same direction of the one found in the panel specification.

The spread of international supply chains and its relationship with import protection cam mask the influence of other determinants of import tariffs. To control for any confounding effects, I thus add explanatory variables in the matrix X of regression (1). I include the output-to-import ratio because, as explained above, it should capture political economy

[4] Koopman et al. (2014) refer the the VS share as the foreign content of gross exports.

incentives for trade protection also in the presence of traded intermediates. Intra-industry trade (IIT), whereby countries specialise in different varieties of similar products, is another major feature of international trade. While this type of trade is associated with gains from additional variety, it creates rents from protection, both in monopolistic competition settings (Chang, 2005) and in models of strategic trade policy (Brander, 1995). This channel hence predicts a positive correlation between IIT and tariffs. I follow Gawande et al. (2011) and add the much used Grubel-Lloyd index of IIT, computed at the HS 6-digit level[5]. Controlling for this aspect of trade is all the more important in my case as supply chain trade often involves intra-industry trade. Governments may set import tariffs purely for optimise their tax revenues. While changes in the overall tax revenue strategy are absorbed in the country-year dummies, revenue-motivated governments would find it optimal to impose higher tariffs on goods with lower import demand elasticity, σ. In those products, a given tariff would lead to lower distortions while obtaining higher revenues than in products with a higher elasticity. As in Broda et al. (2008), I thus control for the inverse of the import demand elasticity σ. Broda et al. (2008) find also that market power, as measured by the inverse of the export supply elasticity (ω), is a significant determinant of tariff protection. By imposing an import tariff, an importer with market power can achieve terms-of-trade gains at the expense of the exporter. Countries that have constrained their MFN tariff under the WTO system should however have limited possibility to exploit their market power because multilateral negotiations are supposedly meant to eliminate the negative externalities from the unilateral terms-of-trade gains from protection (Staiger and Bagwell, 1999). The importance of this proxy for market power is therefore expected to be limited in the countries forming my sample, which are all WTO members except China before 2001 and Taiwan before 2002.

To compute the value-added variables, I use the Asian international input-output (AIO) tables complied by IDE-JETRO (see Meng et al., 2013 for details). They provide harmonised tables of shipments of intermediate inputs and goods for final demand across sectors and countries in 1990, 1995, 2000 and 2005. Nine countries (the seven I use in the study plus the US and Singapore[6]) are consistently included in the four input-output tables. The methodology and assumptions that are used to construct the tables are similar to the ones behind other major efforts to trace the features and complexity of global supply chains - the

[5]The index equals: $GL_{o,d,i} = 1 - \frac{I x_{o,d,i} - m_{o,d,i}|}{x_{o,d,i} + m_{o,d,i}}$, where x are country o's exports to d and m are country o's imports from d. It varies between zero and one and increases with the degree of intra-industry trade - i.e. the degree of overlapping between exports and imports. I first compute the index for each country-pair-product combination and then average the values across trading partners for the seven Asian countries in the sample.

[6]I do not include the US since outside Factory Asia. While Singapore is an important trading hub in the region, it has adopted a zero-tariff policy basically through the period and hence did not go through the tariff cutting imposed by the other countries

WIOD database (Timmer, 2012) and TiVA (OECD-WTO, 2012). For this study, the AIO tables have two major advantages. First, they include an earlier period, 1990, that enables to study unilateral tariff liberalisation, since much of this occurred during the late 80's and early 90's (see Figure 2). Furthermore, their sector classification is more detailed than that of other sources. In their original format, the tables have between 76 and 78 sectors, depending on the year. To perform an empirical analysis over time, I have to harmonise the classification over time, which reduces the number of sectors to 54, out of which 47 have some dutiable products[7]. The re-imported VA share (*ivash* in equation (3)), the VS share in equation (4) and the output-import ratio (in logs to control for the influence of some large outliers) are computed for each four years using the information on industrial value added, shipments of intermediates and final goods and gross output. Despite the precious information provided by the AIO tables, they share most of the same problems and caveats of other similar sources (e.g. matching of trade and production data, imputation procedures) and they often use data for a period around the reference year.

The applied MFN tariffs are sourced from TRAINS at the most disaggregated 6-digit level. Tariffs are matched with the more aggregated AIO industries using a concordance from IDE-JETRO[8]. Also, tariff schedules are normally available every year, but with gaps. I thus average tariffs over five year periods between 1990 and 2010 so that the final sample is composed of four periods - e.g., for the first 1990-1994 period, the tariff equals the within country-product average between 1990 and 1994, while, at the industry-level, values refer to the 1990 AIO table. Detailed trade flows that are used to compute the IIT index of intra-industry trade are from COMTRADE. The same data are used to estimate the import elasticity and the inverse export supply elasticity using the method of Soderbery (2015). Table 1 shows summary statistics of the key variables used in the regressions.

Figure 3 plots the evolution of the re-imported VA share in total imports by country. In line with the numbers of Wang et al. (2013), the shares are tiny - re-imported domestic value-added does not account for more than 4% of total gross imports in our sample - but increasing over time, except for Malaysia. The most remarkable increase is in China, where the share of gross imports that is made of domestic value added went from 0.5% in 1990 to 3% in 2005. The ensuing empirical analysis exploits the more refined information at the industry-level to see whether this variation over time contributes to the changes in import tariffs observed over the same period.

[7] WIOD has 16 non-service sectors and TiVA, in its latest tables, has 19 non-service sectors.

[8] The number of products within each industry varies. Some industries (e.g. Chemicals) include almost 500 six-digit codes, while others (e.g. Iron ore) only a handful of this.

3 Results

I first estimate the panel specification of the model (1), where country-industry dummies help to identify the coefficients of interest out of variation with each country and industry. The regression features also country-year dummies to control for any macro level shocks that can affect the average propensity of the government to use import tariffs. Table 2 show the results.

In columns (1) and (2), I regress the tariff rate on the two VA variables of interests separately, controlling for the output-import ratio in each column. The coefficient on the re-imported VA share of imports has the expected negative and significant sign. Countries reduced tariff protection as imports are made of more domestic value added. The estimates imply that an increase in the import share of re-imported VA by 1% is associated with a tariff cut of 1.3%. Surprisingly, the VS share variable is positively correlated with import tariffs. Controlling for the size of rents from trade protection through the output-import ratio, governments grant higher protection to industries where an additional dollar of gross output provides more payments to foreign factors of production. The positive and significant coefficient on the output-import ratio supports the prediction of the PFS framework. Tariffs increase with the potential for rents extraction (as proxied by gross output) relative to the associated deadweight loss from protection (rising with imports). These findings are confirmed when all the three industry-level variables are included, as shown in column (3). Column (4) adds the other product-level determinants of tariffs. The sample is substantially reduced due missing elasticities and zero trade flows[9]. Despite this, the coefficients on the two VA variables and the output-import ratio do not change substantially. The positive coefficient on the IIT variable gives support to the idea that higher intra-industry trade is correlated with imperfect competition setting and hence the possibility of using tariffs to shift rents across borders. The positive coefficient on the market power variable ($\ln(\omega)$) suggests that, if anything, countries throughout the sample period apply a lower tariff on goods where they can exert market power - as measured by the log of the the inverse export elasticity. This can be a sign that the multilateral system 'works': member countries are forced to place lower tariffs on goos where the negative externalities from terms-of-trade changes for exporters would be greater. Finally, tariff revenue motives do not seem to play

[9] The ITT index is not defined for observations with zero imports and exports. These instances make up around 15% of the sample. Elasticities cannot be estimated with zero or missing information on imported values or quantities, because both are required to compute unit values. This additional constraint reduces the sample size by a further 10%. Finally, the estimated ω was less than zero (and hence inconsistent) in around 5% of the sample.

a role in our sample as implied by the small and not significant coefficient on the inverse of the import demand elasticity - confirming the evidence of Broda et al. (2008).

In the remaining four columns (from (5) to (8)) of Table 2, I take long differences in the data - the difference between the last and the first year of non-missing observation. The elasticity-based variables, being time-invariant, are thus dropped from the estimation.The objective is to tackle directly the key question of the empirical investigation - Do changes in production sharing patterns explain observed changes in import tariffs? Results for the main variable of interest, the re-imported VA share, are very much in line with the panel evidence of the first four columns. Tariff cuts are more prevalent where imports bring back home more domestic value added. The coefficient on the VS share variable is still positive, but much lower and imprecisely estimated than in the full panel specification. Similarly the effect of changes in the output-import ratio is not significantly different from zero, while an increase in intra-industry trade is significantly associated with higher tariffs.

In sum, the estimates provide support for the hypothesis that governments cut their tariffs as the importance of production sharing across borders increases. The tariff-cutting effect of re-imported VA through 'supply-chain' imports further corroborates the view of governments maximizing local value added. The magnitudes implied by the estimates are also important. Using the preferred estimates in column (3), a standard deviation increase in re-imported VA (about 1.2%) would lead to a decrease in tariffs by 1.7%, which is one fourth of the average variation in tariffs over time. Yet, the positive coefficient on the VS share variable suggest that trade protection increases with the importance of value added generated abroad and embodied in domestic production. While this result does not square well with the proposed theoretical arguments, the effect is not robust, which is perhaps due to the fact that foreign value added can enter the country through any industry - there is no specific link to industry-specific tariffs.

In Table 3, I investigate further the observed empirical patterns and estimate the preferred specification (with controls) for each country separately. The negative relationship between re-imported VA and tariffs over time is particularly strong in China and South Korea. In those countries, an increase in the re-imported VA share by one percentage point is associated with more than 5% drop in tariffs, or half of the average tariff variation over time in China and one third of the variation in South Korea. In other countries, the effect is not significant except for Indonesia, where is positive and significant at the 10% level. The estimates on the VS share variable show that governments in China, Japan, Philippines, Thailand and Taiwan increase their tariffs as the share of foreign value added embodied in gross output increases. The magnitude of the estimated effect in China is comparable to the one the re-imported VA variable. An increase in the VS share of 7% (one standard deviation) leads to a tariff that is higher by 5%.

I then go back to the full sample and perform two batteries robustness checks. One concern of the estimation above is that, because of the coarse matching between products and industries, the sample includes industries that are outside manufacturing (e.g. mining, fishing). Services are likely to determine the production sharing arrangements characteristics of these industries, which are here linked to a handful of manufacturing products that end up in the aggregated industry label. When I drop these problematic sectors (columns (1) to (4)), the coefficients on the VA variables do not change significantly, suggesting that measurement error in this subsample is not biasing my estimates. In columns (5) to (8), I thus use the full sample and re-estimate the panel specification with a Tobit estimator that takes into account the censoring of tariffs at zero (see also Broda et al., 2008). The benchmark findings are again confirmed as the estimated coefficient on the re-imported VA share is negative and significant, while the share of foreign value-added in production is positively associated with tariffs over time.

While the main objective of the analysis is explaining variation in tariffs over time, the theoretical arguments suggesting a negative association between the deepening of production sharing and tariff protection should be valid also across sectors. I thus estimate the main regression model in (1) with only country-time dummies, exploiting variation both across products and industries and over time. Table 5 shows the estimates of this 'pooled' specification on the full sample (columns (1) to (4)) and on the sample with manufacturing industries only (columns (5) to (8)). The estimates of the re-imported VA share are consistent with the panel results. Governments give significantly lower tariffs to sectors where imports embed a greater amount of domestic value added. The magnitude of the effect implied by the estimates is however lower than in the panel regressions. Sectors that have a re-imported VA share 1 percentage point lower have also a 1% higher tariff, while the average variation of tariffs across industries almost ten times larger (around 10%). Interestingly, the positive relationship between the VS share and tariffs disappears in the pooled specification, The coefficient is small and never significantly different from zero, suggesting that governments do not differentiate the level of protection across sectors depending on the importance of foreign value added in production. Overall, the evidence on the role of vertical specialisation is rather mix - it leads to higher protection over time (although not in long differences), but it has no significant effect on the structure of protection across sectors. The coefficient on the output-import ratio is instead positive and significant, confirming the panel evidence and much for the existing empirical work on the predictions of endogenous trade policy models.

importantly, these pooled results hold when looking at manufacturing sectors only, as shown in columns (5) to (8). if anything, the effect of the re-imported VA share becomes even bigger, whereas the VS share has again no significant association with tariffs. Finally, Table 6 reports the estimate of the pooled specification by country. As observed for the panel regressions, there is substantial heterogeneity in the estimates. In China, the estimates point to no significant effect of re-imported VA share, while the estimates of Table 3 imply that tariffs went down as sectors re-imported more domestic value added. Across sectors, tariff decrease with the amount of re-imported value added in Japan, South Korea and the Philippines. The coefficient on the VS share variable switches sign across countries, suggesting a positive relationship between tariffs and foreign value added in production in China, Malaysia and the Philippines, while an expected negative sign in South Korea and Taiwan. These stark differences are behind the zero average coefficient found in the full sample (Table 5). A closer look at each of these single countries might shed light on the different patterns observed both over time and across sectors.

4 Concluding remarks

In this paper, I bring together two major developments that shaped the world economy in the recent decades: unilateral tariff liberalisation and global supply chains. Different theoretical arguments suggest a negative relationship between the development of production sharing arrangements across countries and the propensity to impose tariff barriers. I thus test empirically whether the increase in importance of global supply chains affects import tariffs over time, looking at the case of seven countries in East Asia that at the core of the 'supply chain revolution' - and at the centre-stage of Factory Asia. I find that tariffs decrease significantly with the complexity and importance of production sharing, as measured by re-imported valid added as a share of gross imports - i.e. value added that initially left the country and that then, through the supply chain, re-enters the country for consumption or further processing. The effect is sizeable and robust to different specifications and most important in China and South Korea. Another common measure of global supply chain, the share of foreign value added in production, is positively associated with tariff protection, although the effect is less strong and robust than the one of the re-imported VA share. In sum, the increasing complexity of international input-output linkages has weakened protectionist forces within countries and contributed towards a level-playing field in tariffs.

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List of figures

Figure 1: VS share over time

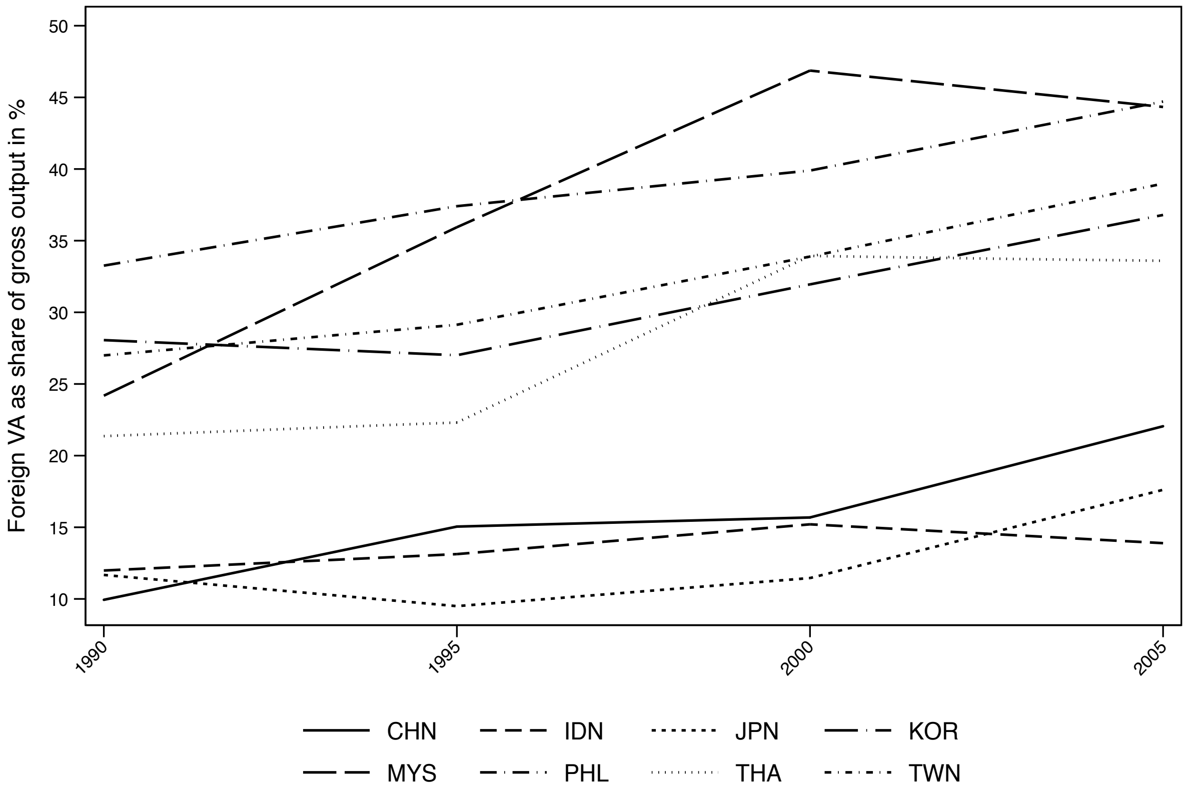


Figure 2: Average MFN tariff overt ime

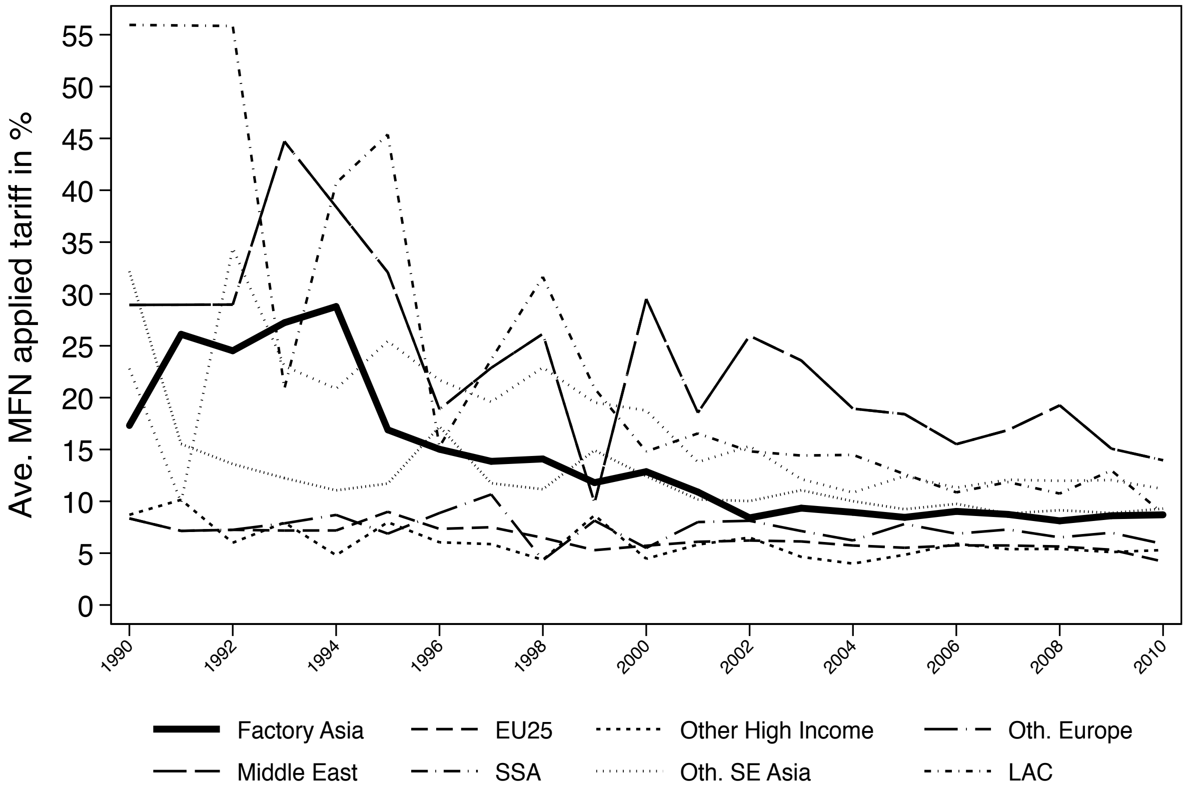
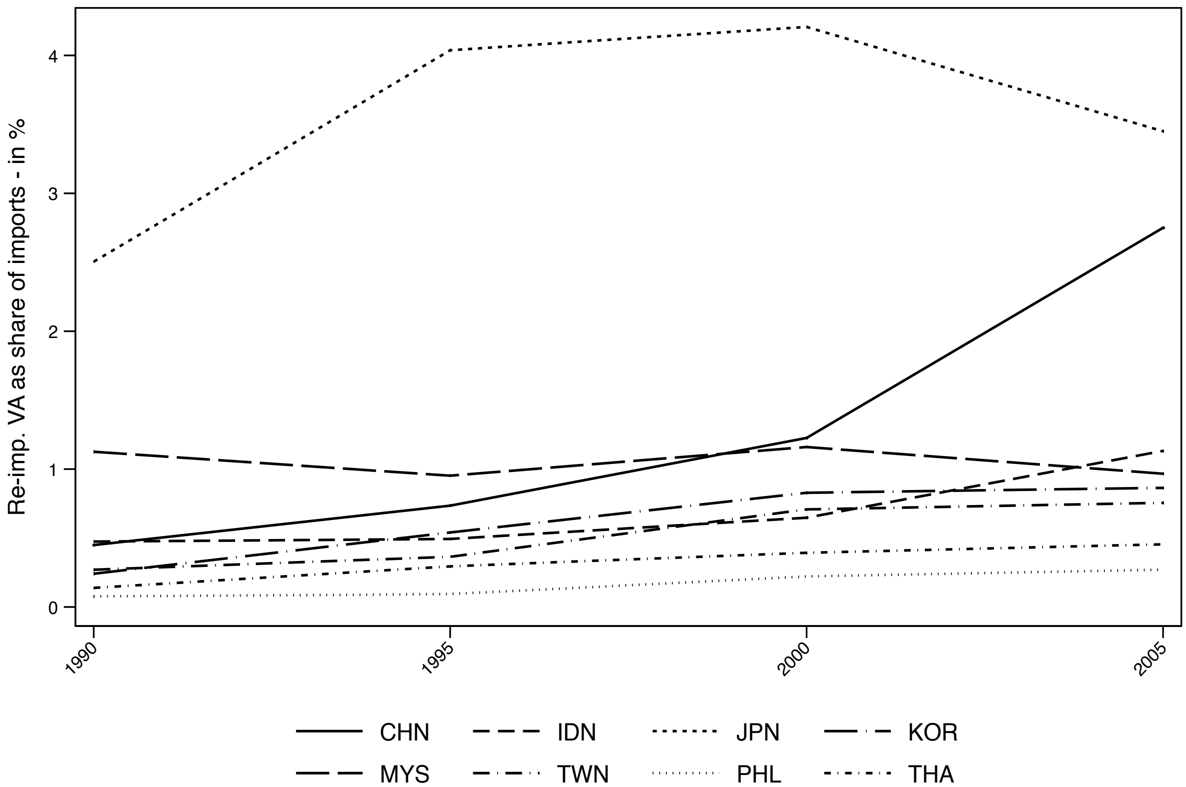


Figure 3: Re-imp. VA share over time



List of tables

Table 1: Summary statistics

	Obs	Mean	Std. dev.	Min	Max
Tariff	164335	0.127	0.197	0.000	11.946
Re-imp. VA share	164335	0.009	0.012	0.000	0.118
VS share	164335	0.282	0.142	0.000	1.000
Ln(output/import)	164335	1.492	1.412	-17.133	16.050
IIT	148439	0.283	0.266	0.000	1.000
$\ln(\omega)$	97062	-0.349	1.677	-9.943	3.658
$\ln\left(\frac{1}{\sigma}\right)$	143995	-1.182	0.906	-4.904	-0.003

Table 2: Tariffs and international supply chains - Panel regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel				Long Difference			
Share re-imp. VA	-1.321**		-1.374**	-1.613**	-3.022**		-2.988**	-2.476**
	(0.612)		(0.594)	(0.748)	(1.190)		(1.172)	(1.255)
VS share		0.103***	0.106***	0.155***		0.0498	0.0360	0.130*
		(0.0339)	(0.0336)	(0.0448)		(0.0558)	(0.0539)	(0.0758)
ln(output/imp)	0.00765**	0.00701**	0.00738**	0.0108**	0.00160	0.00238	0.00203	-0.00105
	(0.00326)	(0.00314)	(0.00311)	(0.00422)	(0.00591)	(0.00590)	(0.00603)	(0.00701)
IIT				0.0126***				0.0102*
				(0.00286)				(0.00543)
$\ln(\omega)$				-0.000880**				
				(0.000388)				
$\ln\left(\frac{1}{\sigma}\right)$				-0.00181				
				(0.00120)				
Obs	164,335	164,335	164,335	90,668	43,981	44,022	43,981	34,184
R^2	0.443	0.443	0.443	0.518	0.306	0.301	0.306	0.354

Columns (1) to (4) include country-time and country-industry dummies. Standard errors are clustered at the country-industry-time level. Columns (5) to (8) include country and industry dummies. Standard errors are clustered at the country-industry level. Significant at: *10%, **5%, ***1% level.

Table 3: Tariffs and international supply chains - Panel regressions by country

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CHN	IDN	JPN	KOR	MYS	TWN	PHL	THA
Share re-imp. VA	-5.344***	3.060*	0.0625	-5.296**	0.552	0.120	0.822	-2.096
	(1.357)	(1.692)	(0.0860)	(2.416)	(0.497)	(0.387)	(2.846)	(4.407)
VS share	0.825***	-0.0612	0.0437*	-0.0191	0.0341	0.100***	0.0581*	0.407*
	(0.162)	(0.0743)	(0.0237)	(0.0451)	(0.0278)	(0.0305)	(0.0316)	(0.238)
ln(output/imp)	0.000949	0.00758	0.00112	-0.00352	0.00624	0.00384*	0.00599	0.0302*
	(0.0129)	(0.00599)	(0.00305)	(0.00527)	(0.00495)	(0.00231)	(0.00406)	(0.0157)
IIT	-0.00205	0.0418***	-0.00177	-0.0127	0.0460***	0.0117***	0.0150***	0.0182**
	(0.00926)	(0.00718)	(0.00168)	(0.00866)	(0.00867)	(0.00328)	(0.00520)	(0.00902)
$\ln(\omega)$	-0.00413***	0.00111	-0.000557**	0.000371	0.00106	-0.000649	-0.00101	-0.000414
	(0.00142)	(0.00147)	(0.000242)	(0.00110)	(0.000834)	(0.000614)	(0.000705)	(0.00102)
$\ln\left(\frac{1}{\sigma}\right)$	-0.00584**	-0.00599***	5.26e-06	0.0226**	-0.00323	-0.00386***	-0.00112	-0.00506***
	(0.00288)	(0.00211)	(0.000641)	(0.00903)	(0.00200)	(0.00145)	(0.00175)	(0.00168)
Obs	13,198	12,036	10,447	11,976	10,558	11,335	8,647	12,471
R^2	0.607	0.541	0.619	0.101	0.429	0.533	0.689	0.713

All columns include industry and time dummies. Standard errors are clustered at the industry-time level. Significant at: *10%, **5%, ***1% level.

Table 4: Tariffs and international supply chains - Panel regressions; Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Only manufacturing			Tobit				
Share re-imp. VA	-1.092*		-1.128*	-1.426*	-2.338***		-2.395***	-2.466***
	(0.605)		(0.585)	(0.749)	(0.779)		(0.757)	(0.890)
VS share		0.109***	0.110***	0.156***		0.0993**	0.104***	0.156***
		(0.0356)	(0.0353)	(0.0453)		(0.0390)	(0.0380)	(0.0475)
ln(out/imp)	0.00961**	0.00874**	0.00903**	0.0118***	0.00810**	0.00754**	0.00801**	0.0109**
	(0.00391)	(0.00372)	(0.00369)	(0.00454)	(0.00343)	(0.00343)	(0.00330)	(0.00432)
IIT				0.0132***				0.0214***
				(0.00291)				(0.00337)
$\ln(\omega)$				-0.000506				-0.00152***
				(0.000375)				(0.000475)
$\ln\left(\frac{1}{\sigma}\right)$				-0.00217*				-0.00195
				(0.00117)				(0.00134)
Obs	152,971	152,971	152,971	86,600	164,335	164,335	164,335	90,668
R^2 0.517	0.517	0.517	0.582					

All columns include country-time and country-industry dummies. Standard errors are clustered at the country-industry-time level. Significant at: *10%, **5%, ***1% level.

Table 5: Tariffs and international supply chains - Pooled regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full sample				Only manufacturing			
Share re-imp. VA	-1.043***		-1.010***	-0.894***	-1.336***		-1.332***	-1.171***
	(0.231)		(0.225)	(0.234)	(0.270)		(0.269)	(0.266)
VS share		-0.0345	-0.0267	0.0222		-0.0184	-0.0162	0.0269
		(0.0303)	(0.0299)	(0.0322)		(0.0279)	(0.0275)	(0.0321)
ln(out/imp)	0.0298***	0.0278***	0.0288***	0.0343***	0.0374***	0.0355***	0.0369***	0.0403***
	(0.00266)	(0.00306)	(0.00308)	(0.00336)	(0.00315)	(0.00346)	(0.00348)	(0.00427)
IIT				0.00159				0.00351
				(0.00603)				(0.00597)
$\ln(\omega)$				-0.000986				-0.000427
				(0.000699)				(0.000660)
$\ln\left(\frac{1}{\sigma}\right)$				-0.00861***				-0.00865***
				(0.00231)				(0.00230)
Obs	164,335	164,335	164,335	90,668	152,971	152,971	152,971	86,600
R^2	0.262	0.261	0.263	0.347	0.324	0.321	0.324	0.402

All columns include country-time dummies. Standard errors are clustered at the country-industry-time level. Significant at: *10%, **5%, ***1% level.

Table 6: Tariffs and international supply chains - Pooled regressions by country

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CHN	IDN	JPN	KOR	MYS	TWN	PHL	THA
Share re-imp. VA	0.488	0.460	-0.598***	-5.057**	-1.114	1.283	-11.81***	1.622
	(0.911)	(1.094)	(0.168)	(2.469)	(0.788)	(1.039)	(3.013)	(3.034)
VS share	0.526***	0.0821	0.0513	-0.213***	0.187***	-0.255***	0.0838*	0.120
	(0.192)	(0.0509)	(0.0404)	(0.0689)	(0.0441)	(0.0429)	(0.0467)	(0.115)
ln(out/imp)	0.0549***	0.0283***	-0.00923**	0.0206***	0.0370***	0.0176***	0.0287***	0.0777***
	(0.0112)	(0.00505)	(0.00358)	(0.00641)	(0.00602)	(0.00516)	(0.00406)	(0.0148)
IIT	-0.00370	0.0706***	-0.0227***	-0.0554***	0.0733***	-0.00400	0.0347***	-0.000465
	(0.0155)	(0.0129)	(0.00518)	(0.0166)	(0.0108)	(0.00401)	(0.00871)	(0.0212)
$\ln(\omega)$	-0.00487***	0.00346*	-0.000670	-0.00722***	0.00328***	-0.00223***	0.000672	-0.00379**
	(0.00177)	(0.00181)	(0.000477)	(0.00232)	(0.00119)	(0.000784)	(0.00105)	(0.00180)
$\ln\left(\frac{1}{\sigma}\right)$	-0.0113**	-0.0119***	-0.00177	0.00868*	0.00110	-0.0136***	0.000338	-0.0154***
	(0.00490)	(0.00362)	(0.00124)	(0.00503)	(0.00307)	(0.00295)	(0.00270)	(0.00457)
Obs	13,198	12,036	10,447	11,976	10,558	11,335	8,647	12,471
R^2	0.454	0.306	0.141	0.0273	0.0648	0.226	0.546	0.589

All columns include time dummies. Standard errors are clustered at the industry-time level. Significant at: *10%, **5%, ***1% level.