Exploring the policy dimensions of trade in value-added

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INTRODUCTION

Trade statistics, which was considered as a mature field up to very recently, was profoundly shaken by the rise of global production networks. The financial crisis of 2008-2009 and the resulting "Great Trade Collapse" called for new data to explain the closely knitted global inter-relationship that has built-up since the late 1980s. Trade in intermediate goods and services between firms operating from different countries create new interdependencies with their economic, financial, social and environmental implications. Using traditional trade statistics in innovative ways allows mapping more finely the inter-industry linkages connecting production networks. The *TiVA* database, developed by OECD and WTO, links intermediary trade flows with national accounts data to construct international input-output tables and measure the value-added content of trade.

TiVA is much more than a database because it allows deploying the full strength of input-output analysis to investigate forward and backward linkages in an international context. Similarly, the close relationship between input-output models and graph theory allows benefiting from the recent advances in network analysis. Implications for macroeconomic coordination are also straightforward. Measuring the home-country value-added content absorbed in the final demand of trade partners allows to understand better the correlation of business cycles: even if no direct trade takes place with a third country, a macroeconomic recession in this country may affect indirectly home-country exports of intermediate goods through the global value chains.

The present essay presents only a small portion of the analytical potential derived from input-output and graph analysis. Its objectives are didactic and illustrative: because it is only recently that world-wide comparative results are available, the empirics of trade in value-added remains a largely unchartered territory. After presenting the basic methodological concepts, the paper builds on Diakantoni and Escaith (2014) and Escaith and Gaudin (2014) to apply input-output and network analysis to trade in value-added data, exploring the relationships between *TiVA* indicators and trade policy instruments. A conclusion reviews some of the existing statistical shortcomings and the way-ahead for filling the gaps.

1 TRADE IN VALUE-ADDED AND RELATED POLICY INDICATORS: METHODOLOGICAL OVERVIEW

1.1 Input-Output approach in a single country.

Value-added reflects the value that is added by industries in producing goods and services in addition to the cost of inputs required for their production. Practically, it is measured as the difference between the value of output minus the sum of required intermediate inputs of goods and services. It is equivalent to the compensation for labour (Compensation of Employees) and compensation for capital (Operating Surplus), and also includes a component for 'Other taxes on Production'. The data used here follow the definition of value-added (in basic prices) used in the System of National Accounts (1993 SNA).

Tracking the inter-industrial relationships behind the production of goods and services and measuring the value-added that is created in the process is made possible by using input-output tables. Derived from supply-use tables, they reflect the interrelationship between domestic industries and also between those industries and the final demand categories (households, government, investment and exports). They also reveal how imports are used in producing goods and services (intermediate inputs) and what is the proportion of imports that are consumed (final goods and services).

1.1.1 The basic circuit of goods and services

In a simple two-sector economy (for example, Sector 1: Goods, Sector 2: Services) the real flows of goods and services are as follows:

Table 1 Flows of goods and services in a simple two-sector economy

Sectors	Intermediate demand 1	Intermediate demand 2	Final domestic demand	Exports	Total output
Sector *1*	Z_{11}	Z_{12}	F_1^d	E_1	X_1
Sector *2*	Z_{21}	Z_{22}	F_2^d	E_2	X_2
Imports	M_1	M_2	M_f		
Value Added	VA_1	VA_2			
Total	X_1	X_2			

Notes: Z_{ij}: intermediate consumption of products from sector *i* by *j*; F_i^d: final domestic demand for products produced by *i* = 1,2 or imported from rest of the world ("RoW"); E_i: exports of i to Rest of World (RoW). M_i: imports of intermediate goods used by sector *i* (*i*:1,2) and of final goods for domestic consumption (M_f) from RoW; X_i: total production of *i* ; VA_i: value added (factorial services, corresponding to labour and capital compensation and net indirect taxes).

The horizontal lines show the use of goods and services in supplying other firms, final consumers and rest of the world (exports). The vertical columns describe the production requirements of sector j: purchases of inputs from domestic and rest of the world suppliers, remuneration of factors of production (fundamentally, capital and labour, equal to the value added).

Inter-sectoral relationships are represented by Z_{ij}. The technical coefficients conforming the input-output matrix (I-O) are derived by normalizing the value of intermediate transaction Z_{ij} by the value of total production ($a_{ij}= Z_{ij}/X_j$). These I-O coefficients present the direct requirements of inputs from "*i*" for producing one unit of output of industry "*j*". For example, to produce one unit of output, sector 2 will require a_{12} units from sector *1*.

Technical coefficients tell only part of the story of the productive chain. In order to be able to produce the a_{12} units demanded by sector *2*, sector *1* will need some inputs from sector *2* ($a_{21}.a_{12}$ units). To satisfy the demand created by one additional unit of output in sector 2, individual firms in each sector *1* and *2* will also require inputs produced by suppliers operating from the same sector (a_{22} and $a_{22}.a_{12}$). And so on, as the indirect demands generated at every step create in turn additional requirements.

It can be shown that the feed-back sequence resulting from the initial demand injection can be obtained by the limit of the series $\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \dots + \mathbf{A}^t$

Where:

I is a diagonal identity matrix representing the initial demand injection and A is the input-output matrix. **A** is the matrix of technical coefficients (a_{ij}) and $\mathbf{A}^t$ is the progressive impact of initial demands at the t^th stage of the production chain.

When time "t" tends towards infinity, the series has a limit (known as Leontief Inverse Matrix)

$$\mathbf{L}=(\mathbf{I}-\mathbf{A})^{-1} \qquad [1]$$

The coefficients l_{ij} of the Leontief Inverse measure the depth (intensity) of the backward linkages between sectors. They describe entirely the direct and indirect flows of intermediate products involved by the productive chains. The value of the total output of the economy is given by the sum of the vector **Zu** of intermediate consumption (value of inputs used for sectoral production) and the vector **Y** of final demand (consumption, investment, exports):

$$\mathbf{X} = \mathbf{Zu} + \mathbf{Y} \qquad [2]$$
$$\mathbf{X} = \mathbf{AX} + \mathbf{Y} \qquad [3]$$
$$\mathbf{X} = \mathbf{L}^{-1}\,\mathbf{Y} \qquad [4]$$

Where

Y is the nx1 final demand vector; **X** is the *n*x1 vector of total production (*n* being the number of industries, 2 in our example); **Z** is the *nxn* matrix intermediate consumption of products from sector *i* by *j*, **u** a summation vector (*1xn*) and **L** is the *nxn* Leontief inverse.

An important disclaimer is called for at this stage. Leontief model and its derived indicators are fundamental for understanding the economic background of what statisticians observe through supply-use tables. Yet, any attempt at using them for simulation or forecasting purpose is severely constrained by a series of statistical or economic considerations. In the first category, the modeller needs to consider that the Leontief model is a (final) demand-side framework and all supply-side implications are endogenous; the peculiarity of the fixed-coefficients Leontief production function may also be a limitation when using the model for long term simulation. [1]

1.1.2 The open circuit of goods and services

In an open economy where firms are vertically integrated, firms may import their intermediate inputs from external suppliers or sell goods for further processing to other non-resident industries. International I-O matrices extend the description of inter-sectoral linkages by disaggregating imports and exports between intermediate and final goods, identifying for intermediate goods their countries and sectors of origin/destination. In this multiple region input-output context, the vector of final demand **Y** becomes a *cxc* matrix, *c* being the number of countries included in the model.

For illustrative purpose, let's follow a typical text-book example of two countries with different natural resources and capital endowments. Country A produces manufacture goods and country B primary goods; services are non-tradable products.A two-country/two-sector model would look like Table 2.

Table 2 ***Flows of goods and services in a two-country two-sector model.***

Sectors/country	Country *a* Intermediate demand of sector *1*	Country *a* Intermediate demand of sector *2*	Country *b* Intermediate demand of sector*1*	Country *b* Intermediate demand of sector *2*	Final demand	Exports for final use
Country *a* Sector *1*	Z^{aa}_{11}	Z^{aa}_{12}	Z^{ab}_{11}	Z^{ab}_{12}	$F^{a}_{1}+E^{b}_{1}$	E^{a}_{1}
Country *a* Sector *2*	Z^{aa}_{21}	Z^{aa}_{22}	Z^{ab}_{21}	Z^{ab}_{22}	$F^{a}_{2}+E^{b}_{2}$	E^{a}_{2}
Country *b* Sector *1*	Z^{ba}_{11}	Z^{ba}_{12}	Z^{bb}_{11}	Z^{bb}_{12}	$F^{b}_{1}+E^{a}_{1}$	E^{b}_{1}
Country *b* Sector *2*	Z^{ba}_{21}	Z^{ba}_{22}	Z^{bb}_{21}	Z^{bb}_{22}	$F^{b}_{2}+E^{a}_{2}$	E^{b}_{2}
Value Added	VA^{a}_{1}	VA^{a}_{2}	VA^{b}_{1}	VA^{b}_{2}		
Total	X^{a}_{1}	X^{a}_{2}	X^{b}_{1}	X^{b}_{2}		

Notes: See Table 1. For illustration purpose, the presentation of exports slightly differs from the actual structure of an international IO model.

Table 3 Numeric example of a two-country two-sector economy circuit

	A1	A2	B1	B2	FDd Domestic products	Exports for final demand	FDt Imported product
A1:Goods	8	5	5	2	70	10	80
A2: Services	25	25	0	0	150	0	150
B1:Goods	10	10	5	5	10	10	20
B2: Services	0	0	10	2	13	0	10
V-A	57	160	30	16			
Total output X	100	200	50	25			

Note: monetary values for illustration purpose only.

[1] The dichotomy between endogenous (supply) and exogenous (final demand) variables is irrelevant from a purely *ex-post* descriptive perspective, yet it is fundamental when it comes to modelling. Leontief embodied his model in the short term Keynesian perspective: long term modelling is better (even if never ideally) done using methods which allow substitution effects, such as partial or general equilibrium models.

Gross exports include foreign demand for final use (10 for both A and B) and foreign demand for intermediate use (7 and 20, respectively). In our example, the **A** and **L** matrices are as follows:

Table 4 Two country/sector example: technical coefficients and Leontief matrices

(a) Matrix of technical coefficients [A]				(b) Leontief inverse [L]			
0.08	0.03	0.10	0.08	1.11	0.04	0.15	0.13
0.25	0.13	0.00	0.00	0.32	1.15	0.04	0.04
0.10	0.05	0.10	0.20	0.15	0.07	1.19	0.27
0.00	0.00	0.20	0.08	0.03	0.02	0.26	1.15

Source: based on Table 3

1.2 The measure of trade in value added

Once extended to many countries, International I-O matrices such as the ones described in Table 2, provide a complete picture of the intensity of both macro-economic and inter-industry linkages across borders at a given time. From there, the measure of the value-added content in trade is relatively straightforward. Considering **V** as the *cnxcn* diagonal matrix of value added coefficients obtained by dividing for each country/sector the monetary value of sectoral VA by the value of total production (for example, VA^a_1 / X^a_1);

$V_{ij} = VA^c_i / X^c_i$ when $i = j$ and $V_{ij} = 0$ when $i \neq j$ **[5]**

Then **VA**, the *cnxcn* matrix of value-added coefficients measuring the total direct and indirect value added induced in the whole economy per unit of output, is equal to:

VA = V L [6]

Table 5 shows the resulting coefficient for the two country/sector example.

Table 5 Two country/sector example: induced value-added coefficients

	A1	A2	B1	B2
A1	0.583	0.021	0.073	0.077
A2	0.256	0.923	0.032	0.034
B1	0.147	0.051	0.819	0.219
B2	0.014	0.005	0.076	0.670

Note: the sum of each column equals 1
Source: based on Table 3 and Table 4

Under the hypothesis of homogeneity within the various components of the final demand **Y**, in particular that products that are exported are produced using the same production function (a_{ij}) than other products destined to the domestic market, equation [7] can be used to measure for each individual country the domestic value-added content generated by gross exports in the global economy. [2]

VAE = V L E [7]

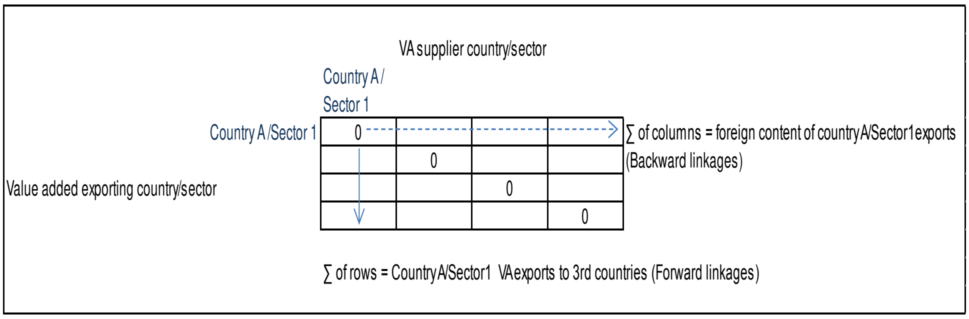
Where **E** is the *cxn* matrix of gross exports and **VAE** is the *cxn* matrix of value-added exports.

Disregarding domestic inter-industrial relationships, **backward linkages between countries/sectors** are defined as the column sums of the Leontief-inverse derived from international IO matrix; they represent the relationship between the activity in a sector and its sales as supplier of intermediate inputs to downstream foreign customers. **Forward linkages between countries/sectors** are measured as the sum over the rows and consider the purchases of imported inputs from foreign suppliers (vertical specialization, as in Hummels et al. 2001). The

[2] A strict interpretation of the international IO framework would call for considering only exports of final products (exogenous variables); yet in practice, most authors extend the measure of VA to exports of intermediate goods despite the fact that those transactions are endogenous to the IIO model. As mentioned in Box 1, the dichotomy exogenous/endogenous variable is fortunately much less relevant from the practitioners' descriptive purpose than it is for modelling or academic intentions.

GVC participation index proposed by Koopman, Powers, Zhi Wang and Shang-Jing Wei (2010) adds the two calculations (columns and rows). It measures the share of foreign value-added embodied in gross exports and domestic contribution to the exports of third countries.

Table 6 Schematic presentation of backward and forward linkages



Derived from the notion of backward and forward linkages, an additional indicator that can be used is the average propagation length (APL) introduced by Dietzenbacher and Romero (2007) and developed by Inomata, 2008. Completing the measure of the strength of industrial linkages, APL allows estimating the length of supply chains, simulating the propagation of supply or demanding shocks demand through the vertical integration of production processes. [3]

Furthermore, setting the diagonal cells of **VLE** corresponding to domestic transactions to zero, one can derive two indicators:

- **Foreign content (intermediates) in gross exports of a country (sum of columns)** = Backward linkages = Hummels Vertical specialization *VS*, when presented as a share in the country gross exports.
- **Domestic intermediates exported to third countries (sum of rows)** = domestic VA inputs of a country that are embodied in exports of other countries = Forward linkages ="*Indirect*" VA exports.

Table 5 shows that, even when services (sectors A2 and B2) are not tradable and therefore do not export directly, they nevertheless contribute *indirectly* to the value-added exported by their respective countries. Extending this simple example to a real case study, it is therefore possible to compute the true contribution of any individual industry to the total domestic value-added exported, be it direct (as the sectoral value-added related to the gross exports originating from the industry) or indirectly, as supplier of inputs to the exporting industries.

In practice, extending **X** and **L** to cover many countries and sectors while maintaining the basic national accounts identities is a challenging statistical process. The measurement issues are also more complex, as some of the exported value-added may return to country of origin as imports of intermediate or final products (see Escaith, 2014, for a general review of the statistical issues; Koopman, Powers, Zhi Wang and Shang-Jing Wei, 2014, for a more detailed discussion of value-added measurement and a generalization of the 2x2 model). Finally, the homogeneity assumption is a rough assumption and may even become unrealistic in some cases (such as China, Mexico) where a large share of exports from some industries are the results of deeply integrated global value chains relying much more on imported inputs than the rest of the economy. In this case, special data manipulations have to take place, such as splitting the IO according to the type of firms (e.g., firms working mainly for the domestic market vs. firms specialising in export processing).

The OECD-WTO *TiVA* database (covering 57 countries, May 2013 release) used in this paper measures trade in value-added by means of the global IO table produced by the OECD. The industry level of detail used includes 37 industries. [4] For analytical purpose, the indicators of direct

[3] For a review and applications of some GVC indicators, see De Backer and Miroudot (2013), Escaith and Inomata (2013) and Zhi Wang, Shang-Jin Wei and Kunfu Zhu (2014).

[4] For further information on the methodology see OECD-WTO (2012) 'Trade in Value-Added: Concepts, Methodologies and Challenges'.

and indirect value-added imbedded in exports were aggregated in three sectors: primary (agriculture and mining); manufacture (other goods producing sectors) and services. The following indicators (Table 7) were derived by differentiating between domestic and foreign value-added and direct vs. indirect contribution (identified itself by its sector of origin).

Table 7 List of Trade in Value Added indicators aggregated by main sector of activity.

Trade in Value-Added Variable	Code	Trade in Value-Added Variable	Code
Manufacture export, domestic VA from Manufacture	M_DM	Services export, domestic VA from Primary	S_DP
Manufacture export, domestic VA from Primary	M_DP	Services export, domestic VA from Services	S_DS
Manufacture export, domestic VA from Services	M_DS	Services export, foreign VA from Manufacture	S_FM
Manufacture export, foreign VA from Manufacture	M_FM	Services export, foreign VA from Primary	S_FP
Manufacture export, foreign VA from Primary	M_FP	Services export, foreign VA from Services	S_FS
Manufacture export, foreign VA from Services	M_FS	Total export, domestic VA from Manufacture	T_DM
Primary export, domestic VA from Manufacture	P_DM	Total export, domestic VA from Primary	T_DP
Primary export, domestic VA from Primary	P_DP	Total export, domestic VA from Services	T_DS
Primary export, domestic VA from Services	P_DS	Total export, total domestic VA from all sectors	T_DT
Primary export, foreign VA from Manufacture	P_FM	Total export, foreign VA from Manufacture	T_FM
Primary export, foreign VA from Primary	P_FP	Total export, foreign VA from Primary	T_FP
Primary export, foreign VA from Services	P_FS	Total export, foreign VA from Services	T_FS
Services export, domestic VA from Manufacture	S_DM	Total export, total foreign VA from all sectors	T_FT

1.3 Derived trade policy indicators: The measure of effective protection

Trade in value added is closely linked to the operation of global value chains (i.e. geographically fragmented supply chains). Cross-border transaction costs play a much larger role in this type of vertically integrated trade within value chains compared to traditional trade in final goods. Indeed, vertical specialisation leads to goods crossing national borders more times before reaching the final consumer (Yi, 2003; Ma and Van Assche, 2010; Ferrantino, 2013). Tariffs, for example, may add up to a significant level by the time the finished good reaches customers; similarly, protection against imports of intermediate goods and services increases the domestic cost of production (measured in Diakantoni and Escaith, 2014) and reduce a country's ability to compete in export markets. As we shall see, the impact of protectionism directly and indirectly extends to domestically produced goods and services. Actually, tariff and other barriers on imports have an effect similar to an over-valuation of the exchange rate, creating an anti-export bias. [5]

Effective trade facilitation policies and the reduction in tariffs linked to export-led development policies have greatly promoted the economic integration of East Asia. One of the effects was enhancing the competitiveness of companies that have to operate in the demanding market of global value chains both in terms of cost/quality ratio and in terms of timely delivery. (WTO and IDE/JETRO, 2010; Escaith and Inomata, 2014).

Among all cross-border transaction costs, nominal tariffs are certainly the most "*visible*" (at least, they are more easily measured that non-tariff measures).[6] Tariff duties increase the domestic price of tradable goods by adding a tax to their international market price. An important aspect to factor-in at this stage is that when putting a tariff on a line of product, it is not only the domestic price of imported goods that will increase relative to their international level, but the price of all

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[5] In a more general (equilibrium) context the Lerner hypothesis states that the imposition of import tariffs has the same effect as an export tax. Francois and Manchin (2014) build on this effect to analyse emphasise the impact of import protection by exporters. They find that Lerner effects are likely to be magnified with increasing importance of global value chains and production fragmentation, given the importance of imported inputs for exports.

[6] WTO launched ***I-TIP*** in 2013, a public database on NTM measures covering merchandises and services.

goods that are competing with those imported goods. The reason is that domestic producers will be able to raise their prices by the margin of the tariff without running the risk of being out-priced by imports. In other term, the domestic producers will benefit from a rent thanks to the existence of a tariff on their output. [7]

In practice, the rent is not that large because domestic producers will also have to pay a higher price for all their inputs that are also protected by a tariff. Thus, any domestic industry "j" will benefit directly from the tariff applied to the goods it produces (t_j) but will suffer an additional cost because the suppliers producing the inputs required in the production process are also protected by a tariff.

Consider that, for each country "*c*" the monetary value of total output for industry *j* is given (ignoring superscript *c*) by:

$$\boldsymbol{X_j = V_j + \sum_i Z_{ij}} \qquad \textbf{[8]}$$

Where V_j stands for the value-added in sector "j" (remuneration of the primary inputs such as capital, labour, plus net taxes) and Z_{ij} is the cost of intermediate consumptions (domestic and imported) used by the sector "j" from sector "i".

The gross rent accruing to the producers in industry *j* after introducing tariffs is equal to [t_jX_j - X_j] while the additional cost is $\sum_j$ [t_iZ_{ij} - Z_{ij}], with *t ≥ 1 (t= 1 + duty rate).* [8] Simplifying and normalizing, the gross rent per unit of output is equal to the tariff on final good while the additional cost is equal to the weighted average of its intermediate consumption ($\sum_i t_i \cdot a_{ij}$), including those purchased domestically.

For each sector *j* the net effect, per unit of output, is given by the absolute effective protection (AEP):

$$\boldsymbol{AEP_j = \ t_j - \ \sum_{i=1}^{n}(t_i \,.\, a_{ij})} \qquad \textbf{[9]}$$

where $\mathbf{a_{ij}}$ are the elements of the matrix **A** of technical coefficients, t_j is the nominal protection on sector "j" and t_i the nominal protection on inputs purchased from sector "i", including from "j" itself when $\mathbf{a_{jj}} \neq 0$, and firms from a given industry require purchasing inputs from other firms of the same sector of activity.

Thus, there is a clear relationship between IO analysis and measuring the effective impact of tariff policy. This relationship is even more evident when analysing the impact of the tariff on the value-added, instead of the price of the final product. For this, let's calculate what trade analysts call the "effective protection rate" (EPR).

EPR for sector "j" is the difference between the nominal protection enjoyed on the output minus the weighted average of tariff paid on the required inputs as in equation [10] divided by what would have been the net benefits if all prices had been equal to their international process (without tariff)*. It is given by:*

$$\boldsymbol{EPR_j = \frac{t_j - (\sum_i t_i \cdot a_{ij})}{1 - \sum_i a_{ij}}} \qquad \textbf{[10]}$$

With $\left[1 - \sum_i a_{ij}\right] > 0$.

[7] This is a result of the usual profit maximization hypothesis (see Diakantoni and Escaith, 2014, for a discussion).

[8] In other words, in absence of tariff duties on product [*i*] and discarding other transaction costs (freight and insurance), $t_i = 1$ and domestic prices are equal to international ones.

Box 1 Introducing tariffs in a price and quantity input-output framework

Prima facie, the effect of tariff as it was expressed in equation [11] is a change of relative price that could be interpreted as the result of a price shock on the cost of primary factors (e.g., wages, profits or indirect taxes). Such a shock on the price of value-added should be treated as a cost-push effect in a Leontief-dual framework (see Oosterhaven, 1996). Yet, a closer analysis indicates that this effect on the price of value-added is endogenous to an increase in the cost of products, some of them being final goods and others are intermediate consumption. The latter case is not a clear-cut exogenous process that can be analysed through the Leontief or Ghosh viewpoint. Actually, the introduction of tariffs changes our interpretation of the technical coefficients [a_{ij}] from being *quantitative parameters* to *value ones* (i.e., quantities weighted by a price).

If the **A** matrix coefficients are defined as *physical quantities*, [$a_{ij} = Z_{ij}/X_i$] the implicit unit price is constant and equal to 1. If prices are allowed to change under the impact of tariffs, the "*tariff adjusted coefficients*" [a^{NP}_{ij}] become:

$$\mathbf{a^{NP}_{ij} = t_j Z_{ij}/t_i X_i = a_{ij} (t_j/t_i)} \qquad [11]$$

with a_{ij} and a^{NP}_{ij} being the **A** coefficients in the respective physical and monetary referents, NP standing from nominal protection on output (t_i) and inputs (t_j). Applying differentiated tariffs changes the relative price of products compared to their international price (set to 1) and affects the monetary valuation of technical coefficients.

Moving from a physical to a monetary analytical framework has theoretical implications on the mathematical or economic properties of the model that have been extensively and intensively debated (see for example Kuenne, 2008 or Mesnard, 2013). From a modelling perspective, the modification in prices changes not only the price of exogenous "*quantities*" but also the endogenous ones (i.e., tariffs duties are not like a VAT on consumers that affect only the price of final goods: the relative price of intermediate consumption is also affected).

Despite its formal relevance, the issue is not such a big one for the practitioners, considering that the input-output framework is used only for as an *ex post* accounting framework (Escaith, 2014). In other terms, all the values, be they parameters or results are observed magnitudes corresponding to a unique outcome than happened in the past. As long as the structural equations of a Leontief or Ghosh models not used for modelling or simulation purpose, the distinction between what is endogenous and what is exogenous is irrelevant and all parameters can be treated as quantities.

Similar critics have been addressed at the use of Effective Protection Rates for analytical and policy making purpose. Any change in tariffs will also change relative prices and therefore affect the arbitraging process that economic agents realize on their respective markets. Mainstream economists recommend using partial/general equilibrium frameworks to model the proximate/ultimate effects of a change in relative prices. On the other hand, practitioners keep on using EPRs as one of their workhorses: EPRs are analytically adequate as long as they are used only as *ex-post* descriptive indicators (Diakantoni and Escaith, 2012).

The formulation most commonly used in tariff analysis follows Corden (1966) and excludes non traded inputs from the calculation of $[1 - \sum_i a_{ij}]$. In practice and in order to simplify data processing, all goods are considered as tradable and all commercial services are treated as non-tradable. Non-tradable inputs are therefore implicitly treated as domestic value added and this is the convention followed in this essay. An alternative approach (Balassa, 1965) used in Diakantoni and Escaith (2012) follows more closely the national accounts concepts. In this case, EPRs can be interpreted as the ratio of the value added obtained considering the given (applied) tariff schedules compared to a situation of free trade and no tariff (MFN-0). [9]

[9] Balassa (1965) treats non-tradable input (assimilated usually to commercial services) as a tradable with a zero tariff; Corden (1966) treats non-traded in the same way as domestic value-added. The EPR denominator is then the value-added by primary factors plus the value of non-traded inputs.

$$EPR_j = \frac{V_j}{V_j^*} \qquad [12]$$

where V_j and V^*_j are the value added in the activity "j" as measured at protection-inclusive domestic prices and undistorted world prices respectively.

If the tariff schedule is flat (all tariff duties being equal), the effective protection on the value added is equal to the nominal protection. Tariff escalation -a typical feature of tariff schedules in many countries, where tariffs on processed goods and much higher than on primary commodities- creates a rent for industries producing manufacture goods for the domestic market. In the presence of tariff escalation, downstream industries producing final goods will benefit from a higher effective protection. Moreover, if the industries are price-makers and apply a constant mark-up percentage to define their selling prices, then the monetary value of the rent will also increase with downstreamness (this essay assumes that all firms are price-takers). [10] Upstream industries producing inputs will have, on the contrary, a lower protection and possibly a negative one if the sum of duty taxes paid on the inputs is higher than the taxes collected on the output.

This was the intended result when trade policies in developing countries were driven by the industrialization by import substitution (ISI) strategy. Steep tariff escalation biases production techniques in favour of using upstream unprocessed inputs against more elaborated (and often imported) processed inputs. For lesser advanced developing countries, this has an unintended adverse impact on the quality of the finished good and its technological content when technical progress is embodied in investment and intermediate goods produced by the foreign countries that lie on the production frontier. It may reduce the potential for technological up-grading; in a neo-classic referent *à la Solow*, it slows-down productivity and income convergence when technological progress is embodied in imported intermediate goods (especially those produced by more advanced industrialised countries). In developed countries that are also the main global demand drivers, an escalated structure encourages developing countries to continue exporting unprocessed goods.

Tariff escalation creates a significant anti-export bias for the protected industries, because the value-added generated by sales on the domestic market (domestic prices) is higher than what can be expected when exporting (international prices), while firms still pay the "protection tax" on their inputs. [11] A practical consequence of such anti-export bias for the trade in value-added indicators is that high effective protection is expected, *ceteris paribus*, to depress the direct and/or indirect domestic content of gross exports (when domestic inputs are too highly priced compared to the international prices); in other words, high EPRs act as an overvaluation of the home currency.

Unfortunately, there is no symmetry in this bias: industries suffering from a negative effective protection on their domestic market have no incentive to export, as demonstrated in Diakantoni and Escaith (2014): the value-added effect will be negative as long as they pay the domestic price on their inputs; duty draw-backs correct only part of the distortion. The gross margin per unit of output they can expect to realize on their domestic market (left hand side of equation [14] is still higher, or at best equal, to what they could expect by exporting on the international market (right hand side). [12]

$$\left(\mathbf{1} - \left(\sum_i t_i \cdot a_{ij}\right)\right) \le \left(\mathbf{1} - \sum_i a_{ij}\right) \qquad [13]$$

When output for final consumption is produced in global value chains, tariffs have cumulative effects as they apply each time the processing goods cross borders. If the exporting partner had

[10] The standard EPR hypotheses are not fully compatible with monopolistic and heterodox pricing theories, unless domestic firms are price takers (see Diakantoni and Escaith, 2014).

[11] As shown in Escaith and Inomata (2014), even when exporting firms can benefit from duty draw-backs or tariff exemption (as in export processing zones), the cost of the inputs that are sourced domestically remains higher than the imported ones, because second-tier domestic suppliers won't be able to benefit from the duty exemptions. Therefore, tariff exemptions do not eliminate entirely the anti-export bias when the full industrial linkages

[12] As mentioned, the existence of draw-back on duties paid for the imported inputs used in exports solves only part of the issue. It is also important to keep in mind that all the calculation is done in terms of unit value. Obviously, larger volumes on the international market could compensate for lower margin per unit.

itself used imported inputs from third parties for producing the intermediate good, those third party imports will have paid twice import duties: once when imported by the supplier of intermediate product, and then as embodied in the imports from the exporting partner. This cumulative process can be tracked using the backward production linkages identified by IIO frameworks. [13] For example, Miroudot and Rouzet (2013) add-up custom duties levied at all production stages on a selection of OECD and non-OECD countries to obtain the cumulative tariff which has been paid on an import along its production chain. Defining tariff magnification as the ratio of cumulative tariff with the nominal tariff duty it faces on the last border crossing, they find that although nominal tariffs are low in most economies, the cascading effect of tariff duties can add a significant additional cost by the time a good reaches its final user, even within free-trade agreements.

The additional cost of tariff accumulation for the final consumers is probably higher when we consider that, in order to derive net price impacts, the calculation should take into account two effects of opposite signs. First, as we have seen, tariffs not only raise the domestic price of imported products, but also increase the price of locally produced substitutable goods that benefit from less competition. Whatever the source of the increase in cost (an increase in the indirect tax revenues of the State or an increase in the rent of domestic producers), the result on the market price for the final consumer remains the same. Note that this impact on the price of non-imported products is restrained to the domestic market because any export, irrespective of the domestic production cost, would have to be at international price, i.e., without collecting the protectionist rent that local producers enjoy. For exactly the same reason, the extent of accumulative tariff impact is bound by the international prices of competing products: once the weight of accumulated tariff on the production costs along a value chain is too high, the supply chain just stop operating; instead, cheaper substitute components are purchased on the international market. [14]

2 TRADE IN VALUE-ADDED AND TRADE POLICY

If the EPR logic is easy to grasp, calculating the related indicators is a complex data-processing task. Tariffs are officially classified according to the Harmonised System but the actual tariff lines proper to each country are usually more disaggregated than the most granular HS 6-digit level. Tariffs have also to be further aggregated and reclassified in order to coincide with the ISIC classification used in national accounts. Moreover, tariffs may differ in relation to the trade partners: some countries benefit from preferential treatments (full or partial exemption of duties) while other imports are taxed according to the more general "Most Favoured Nation" applied tariff. Diakantoni and Escaith (2014) provide a review of the statistical and data processing aspects.

Table 8 Sample of 53 economies covered in the analysis and their ISO3 codes

Name	ISO3	Name	ISO3	Name	ISO3	Name	ISO3
Argentina	ARG	Finland	FIN	Latvia	LVA	Saudi Arabia	SAU
Australia	AUS	France	FRA	Lithuania	LTU	Singapore	SGP
Austria	AUT	Germany	DEU	Luxembourg	LUX	Slovak Rep.	SVK
Belgium	BEL	Greece	GRC	Malaysia	MYS	Slovenia	SVN
Brazil	BRA	Hong Kong SAR	HKG	Mexico	MEX	South Africa	ZAF
Bulgaria	BGR	Hungary	HUN	Netherlands	NLD	Spain	ESP
Canada	CAN	India	IND	New Zealand	NZL	Sweden	SWE
Chile	CHL	Indonesia	IDN	Norway	NOR	Switzerland	CHE
China	CHN	Ireland	IRL	Philippines	PHL	Chinese Taipei	TWN
Cyprus	CYP	Israel	ISR	Poland	POL	Thailand	THA
Czech Rep.	CZE	Italy	ITA	Portugal	PRT	Turkey	TUR
Denmark	DNK	Japan	JPN	Romania	ROU	United Kingdom	GBR
Estonia	EST	Korea. Rep.	KOR	Russian Fed.	RUS	United States	USA
						Vietnam	VNM

[13] See Diakantoni and Escaith (2012), and Miroudot and Rouzet (2013) for a formal development and an application.

[14] This is particularly true if the parts and components are standardized and can be easily sourced from other suppliers; the situation of truly monopolistic value-chain is different as the additional cost can be more easily transferred to the final consumers. This explains, *inter alia*, the non-linear response of GVC trade to transaction costs, as in Yi (2003). Taking into consideration these substitution effects are better treated in a general equilibrium framework and falls outside the purpose of this paper.

The results were obtained for the 53 economies mentioned in Table 8, aggregating the main sectors of production and producing the indicators listed in Table 9. The calculation builds on OECD-WTO *TiVA* database for trade in value-added and WTO IDB database for tariffs. When additional data are called for (such as macroeconomic and structural variables), they are sourced from World Bank WDI database. For both practical and analytical reasons, the study focuses on 2008, just before the 2008-2009 crisis.[15]

Table 9 List of nominal and effective tariff indicators disaggregated by sector.

Tariff indicators / codes	
Nominal Protection at Most Favoured Nation, including Ad Valorem Equivalents, for each good producing sector of *TiVA*	NP_j
Effective Protection Rate (including AVEs), for each good producing sector of *TiVA*	$EPro_j$
Absolute Effective Protection (numerator of the EPR, including AVEs), for each good producing sector of *TiVA*	AEPR
Difference between "NP at MFN" and "NP including preferences", for each good producing sector of *TiVA*	NP_j_dP
Difference between Effective Protection Rate at MFN and including preferences	$EPro_j$_dP
Difference between Absolute Effective Protection at MFN and including preferences	$AEPR_j$_dP
***J:* Good producing sector codes/names**	
001 - Agriculture, hunting, forestry and fishing 002 - Mining and quarrying 003 - Food products, beverages and tobacco 004 - Textiles, textile products, leather and footwear 005 - Wood and products of wood and cork 006 - Pulp, paper, paper products, printing and publishing 007 - Coke, refined petroleum products and nuclear fuel 008 - Chemicals 009 - Rubber & plastics products 010 - Other non-metallic mineral products 011 - Basic metals 012 - Fabricated metal products, except machinery & equipment	013 - Machinery & equipment, nec 014 - Office, accounting & computing machinery 015 - Electrical machinery & apparatus, nec 016 - Radio, television & communication equipment 017 - Medical, precision & optical instruments 018 - Motor vehicles, trailers & semi-trailers 019 - Other transport equipment 020 - Manufacturing nec; recycling (include Furniture)

Source: Diakantoni and Escaith (2014) and Escaith and Gaudin (2014)

2.1 Trade in Value Added Profiles

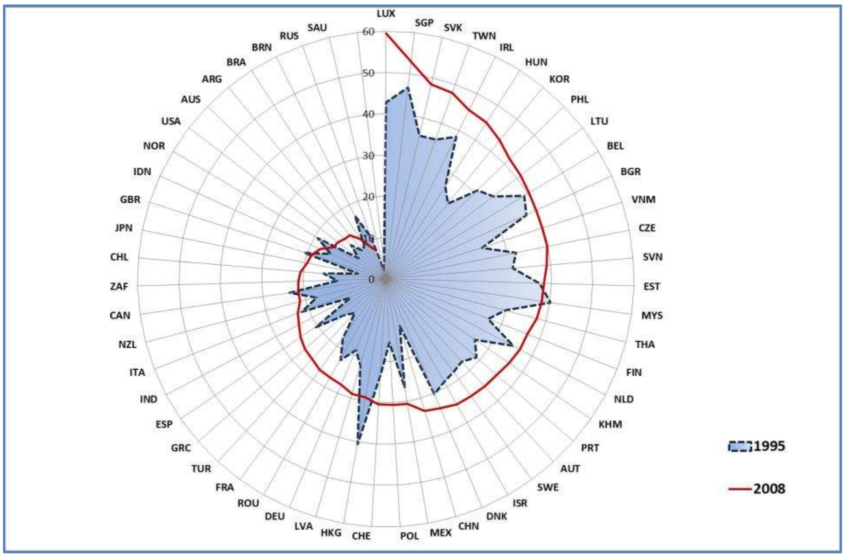
This section will briefly present some of the most salient features observed in the data. Interested readers are invited to refer to the two accompanying papers for more detailed analysis. [16]

The first indicator of interest is the *VS* indicator proposed by Hummels et al. (2001), which estimates the depth of GVC insertion through reliance on imported inputs. The share of foreign value-added embodied in gross exports of goods and services varies widely from country to country (Figure 1) but has usually increased between 1995 and 2008. The lowest-ranking ranking countries for the *VS* criterion (i.e., highest domestic value-added content) are exporters of upstream primary product (Saudi Arabia, Russian Federation, Brazil or Argentina); conversely, the countries where the foreign value-added content (VS) is highest are downstream service oriented economies (Luxemburg, Singapore).

[15] At the time of writing the paper, the OECD-WTO *TiVA* database covered the 1995-2009 period. 2009 was deemed not representative due to the deep global crisis and the large swings in international commodity prices and volumes (trade-income elasticity was about 5 during this period, more than twice its long term average). The 2014 *TiVA* release will include more countries and extend the coverage to 2011.

[16] Diakantoni and Escaith (2014) and Escaith and Gaudin (2014)

Figure 1 Share of foreign value-added in gross total exports, 1995-2008

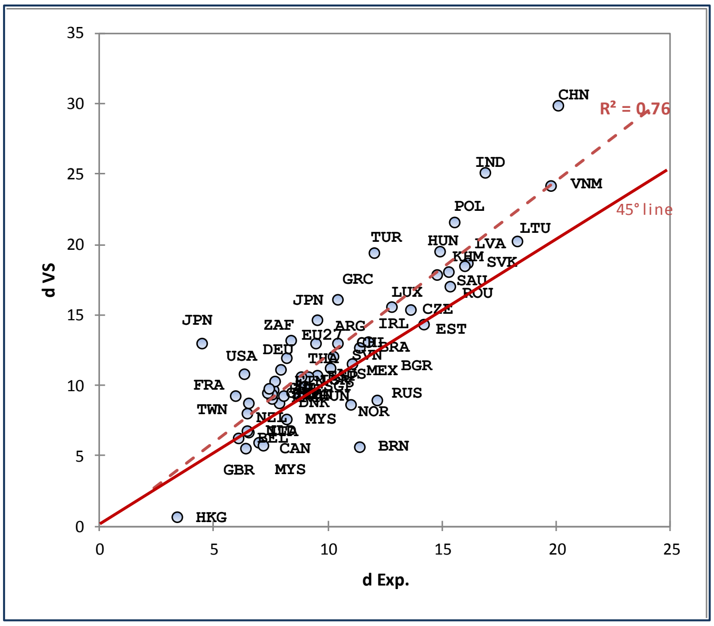


Note: Observations are ranked according to the VS value for 2008 (red line)
Source: Escaith and Gaudin (2014), based on OECD-WTO TiVA database.

Figure 2 illustrates one of the most salient features of Trade in Value-Added: Imports create exports. The correlation between the growth of total exports of goods and services and the imported content in those exports (Vertical Specialization, or VS index) is high (0.76) and significant. All fast-growing exporters (annual export growth greater than 15%) are above the 45° line, meaning that they increased their foreign imports of intermediate inputs more rapidly than their gross exports did.

As long as GVC-based exports are new activities originating from green-field investments and do not crowd-out traditional exports (conditions usually found in most developing countries), trade in tasks is a win-win option. For mature industrialised countries where there may be substitution effects between fully integrated production and vertical specialization, the net outcome in terms of domestic value-added and jobs may be more difficult to establish. Even for industrialised countries, GVC trade is an opportunity. As the Swedish Kommerskollegium points out (Isakson and Wajnblom, 2011), for firms in developed countries, "having a large or small proportion of imports within production or exports is not an end in itself, what is important is that companies become competitive". Using input-output calculations, the authors indicate that imports helped Swedish exports to increase their revealed competitive advantage: Between 1995 and 2005 the contribution of domestic value-added exports to GDP increased from 27% to 31 % even if *VS* –the imports proportion of exports– increased. Using the wider EU perspective, Timmer *et al.* (2013) look at the GVC implications for employment as European competitiveness shifts from manufacture to services. Their results highlight the higher relative demand for high-skilled workers and the uneven distributional effects in industrialised resulting from technical progress and the rise of developing countries' manufacturing exports.

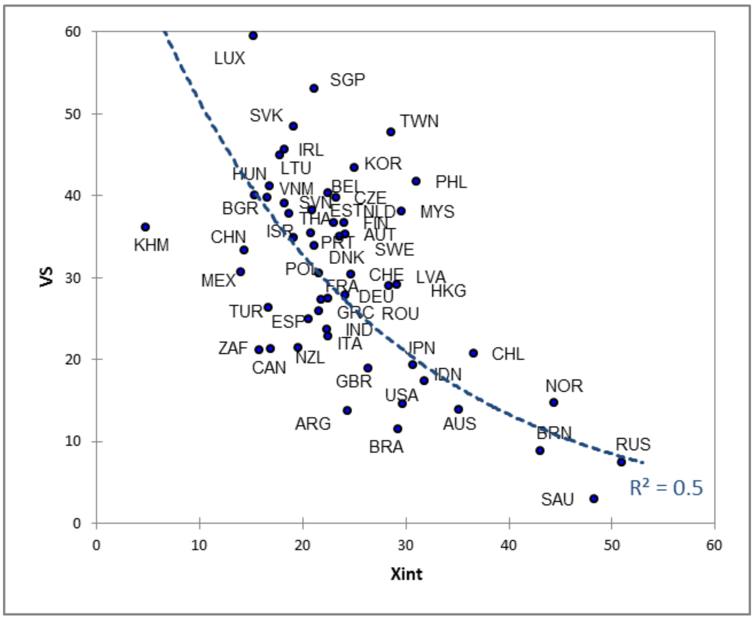
Figure 2 Vertical Specialization and Export Growth, 1995-2008



Note: Vertical Specialization (*VS*) measures the value of imported inputs, parts and components participating in the production of exports. The graph shows annual changes between 1995 and 2008 (%)
Source: Based on OECD-WTO TiVA database.

GVC participation is also characterized by the weight of domestic value-added that is exported for further reprocessing by foreign countries rather than for final use (Figure 3).

Figure 3 Global Value Chain Participation: foreign content and domestic exports of intermediate inputs, 2008



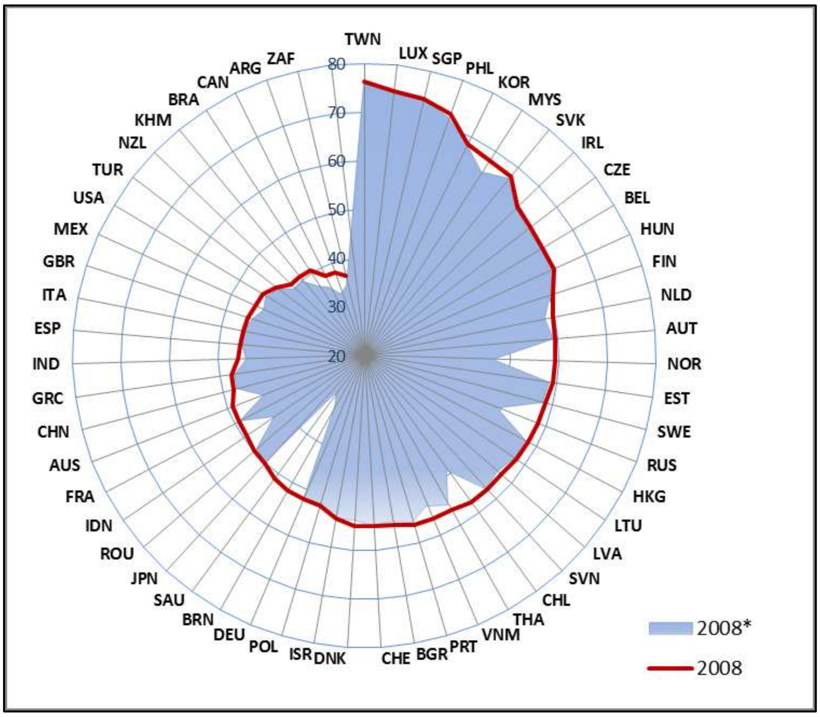
Note: VS: Foreign value-added content; Xint: Domestic value-added exported for further intermediate use by foreign countries.
Source: Based on OECD-WTO TiVA (May 2013 release).

While *VS* tends to be higher for countries specializing in downstream activities (closer to final demand), natural resources rich countries will tend to score high on the second component of the GVC participation index. For example, the Russian Federation and Saudi Arabia are mainly exporting upstream products (fuels and oil derivatives) that are key inputs for downstream value chains. Their exports are key precursor inputs for many global value chains.

Yet, if the GVC participation index makes sense from the backward-forward linkages perspective of input-out analysis, it is not fully satisfying from a trade theory point of view. The new "new" trade theory is mainly about firm heterogeneity and product differentiation. It is in this context that GVCs prosper, being both flexible and able to produce differentiated products at low unit cost. Primary commodities are generally undifferentiated products that are perfectly substitutable in normal times. They do not necessarily imply the GVC-type of long term relationship between sellers and buyers as they are commonly traded on large spot markets. [17] I propose here to correct for this bias by considering only the exports of domestic value added originating from the secondary or tertiary sectors (including, however, the indirect exports of embodied value-added from primary sectors).

Figure 4 presents the traditional calculation of the GVC participation index for 2008 and our adjusted value once direct exports of commodities are taken out (2008*). Once corrected for the direct primary content in the downstream use of domestic value added for further processing in third countries is taken into account, some natural resources exporters like Saudi Arabia, Norway or Russia show much lower insertion in GVCs.

Figure 4 Global Value Chain Participation: Original and Adjusted Index, 2008



Note: The red line shows the participation index in its original definition and the blue area the adjusted value once direct exports of commodities are taken out.
Source: Adapted from Escaith and Gaudin (2014), on the basis of OECD-WTO TiVA

The ranking obtained in Figure 4 changes when adding *forward* GVC linkages to the *backward* VS relationship (Table 10). Even after correcting, as we did, for bias related to exports of raw commodities, large exporters of natural resources like the Russian Federation or Chile gain several places. Interestingly, Mexico (which is also an oil producer) losses 16 places: exports of natural-resources based products are now marginal compared to its GVC-related manufacturing exports. At the other extreme of the spectrum, Japan, despite being poor in natural-resources, gains 14 ranks, indicating its role as key provider of manufactured inputs for further processing.

[17] Obviously, there are exceptions as it may a large downstream firm's business strategy to acquire mining or agricultural enterprises in order to secure its source of supply. If this integration strategy was common during most of the 20th century, since the 1990s, firms tend instead to focus on their "core business".

Table 10 GVC insertion indicator: Top/Bottom ten ranking gains when considering forward linkages

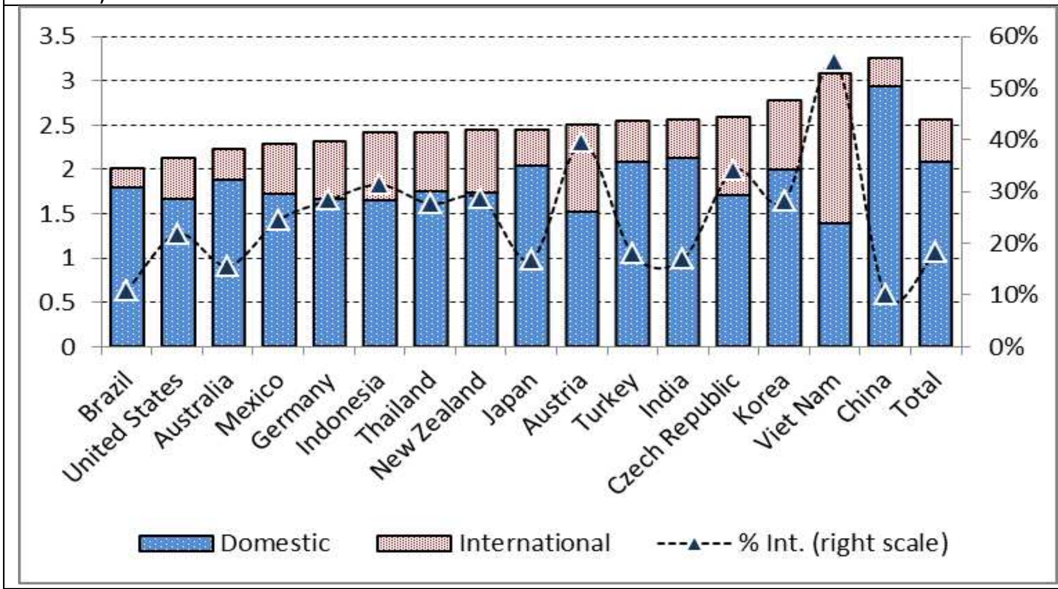
ISO3	*Losses*	*ISO3*	*Gains*
KHM	-27	SWE	6
MEX	-16	USA	6
VNM	-15	AUT	9
BGR	-13	MYS	9
CHN	-10	NOR	10
CAN	-9	CHL	11
LTU	-9	LVA	11
TUR	-9	HKG	14
ZAF	-9	JPN	14
NZL	-8	RUS	22

Note: Rank based on VS indicator minus the rank based on our Adjusted GVC Participation Index (excluding direct exports of commodities): a positive value represents a gain in ranking (see Box 1 for more details).

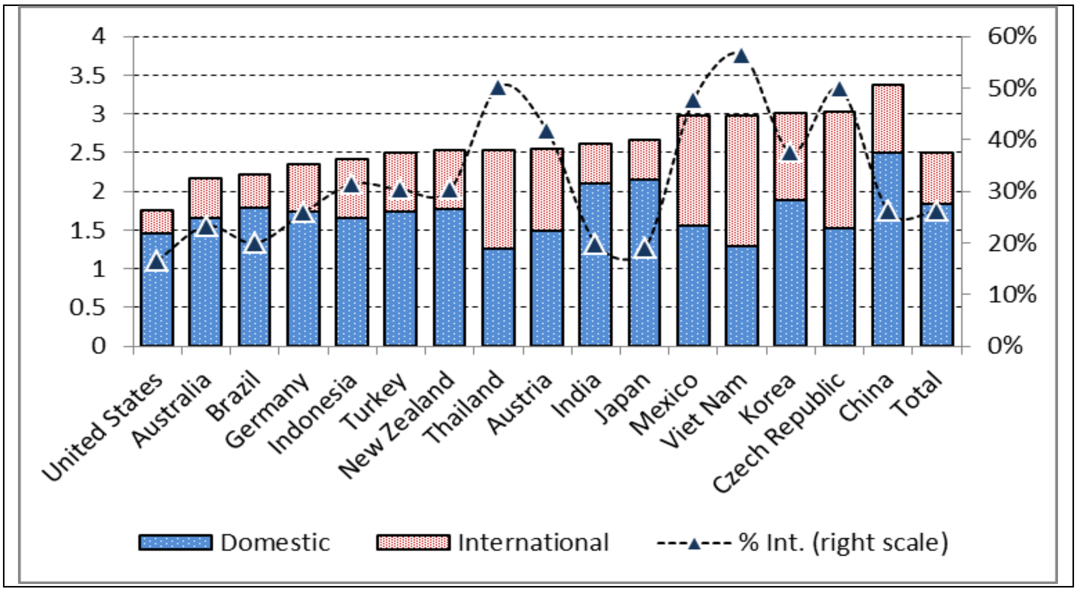
The length of the international part of supply chains (the one being subject to cumulative tariffs) varies from country to country and sector to sector. Figure 5 shows the total number of production stages (i.e., involving the participation of several industries) as measured by international IOs such as *TiVA*. This number is relatively small (less than 2 when all good and services industries are covered) and 12% of them takes place in a foreign country. Yet some words of caution are called for when interpreting the indicators: because input-output coefficients aggregate all firms, large and small, internationally integrated or dedicated only to their local market, the weight of the international share of the supply chain is underestimated for vertically specialised global firms. Moreover, *TiVA* has a low level of industrial detail and the indicator suffers from an aggregation bias (the more aggregated are the sectors of activity, the smaller will be the number of different production stages).

Figure 5: Number of production stages, 2008

Textile, leather and footwear



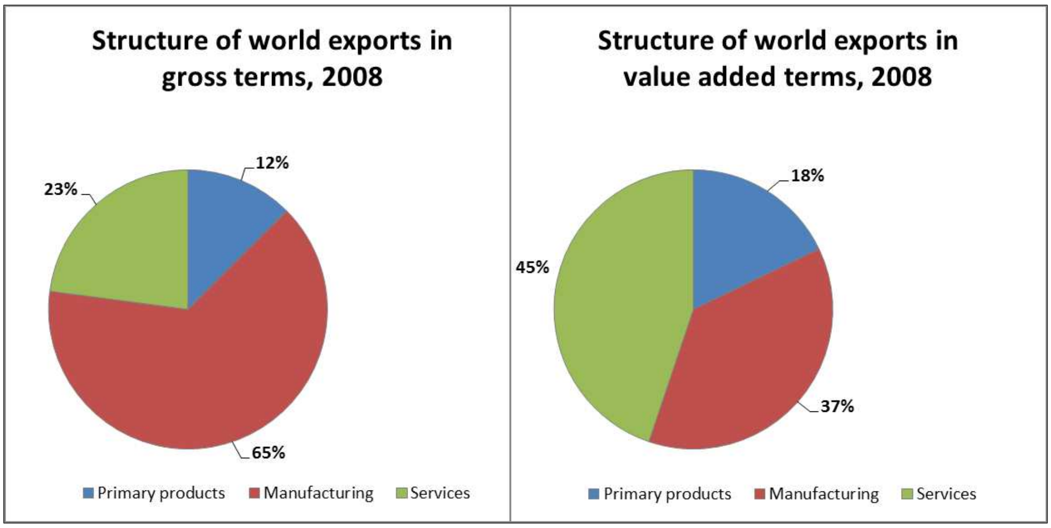
Electrical and optical equipment



Source: Diakantoni and Escaith (2014) on the basis of OECD-WTO *TiVA* Indicators, May 2013.

Another outstanding result of the measure of Trade in Value Added is resizing the role of commercial services in international trade. The production cost of most goods, in particular complex manufactures, includes a large share of embodied services. Measuring trade in direct and indirect value-added terms doubles the relative importance of services. When measured according to the origin of sectoral value-added, 45% of total trade consist, one way or another, of commercial services (Figure 6). As mentioned by Cernat and Kutlina-Dimitrova (2014), the four modes of supply for trade in services contemplated by the GATS do not adequately cover the embodied services value-added trade that is subjected to the same tariff duties than trade in goods. [18]

Figure 6 Structure of world exports in gross and in value-added terms, 2008



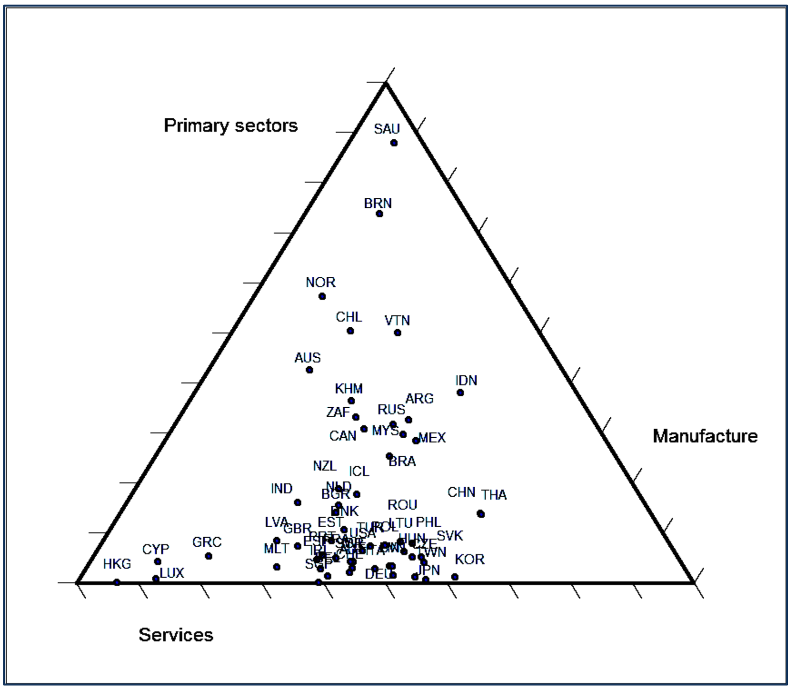
Source: OECD-WTO TiVA database.

A trade in value-added profile can be extracted from the composition of the domestic value-added content (direct and indirect) of gross exports. The Northern sector of Figure 7 concentrates the exporters of natural resources, with low manufacturing and services contents: The score of Saudi Arabia, for example is 88%, 7%, 5%. South-West area projects economies that are low in their primary and secondary share of exported value-added. Illustratively, Hong Kong is close to 0 for the primary sector content, less than 10 for manufacture and more than 95 for services. South-

[18] The authors mention those embodied services as a new indirect mode of services supply.

East corner clusters the economies with a high specialization in manufacture (there is no pure case for such a specialization in the graph: high manufacture content is always associated with either primary sector or services contribution).

Figure 7 Profiling the domestic Value-Added composition of gross exports, 2008



Note: Primary, secondary and tertiary sectors value-added contribution as a percentage of domestic content of gross exports. The plot shows the ratios of the three variables as positions in an equilateral triangle.
Source: Based on OECD-WTO *TiVA* database.

When clustering the economies on the basis of their sectoral contribution (Table 11), one finds that (i) primary content splits the observations in two groups (with and without) while (ii) services content is a scaling dimension that increases through the three patterns (Table 11). Manufacture content is the less discriminant dimension (manufacture oriented economies have the same value-added contribution from secondary and tertiary sectors).

Table 11 Example of clustering based on the sectoral composition of domestic value-added, 2008

Class (*and its centroid*)	**1 (*KHM*)**	**2 (*POL*)**		**3 (*MLT*)**
- Primary (%)	36.3	7.5		3.2
- Manufacture (%)	26.4	46.3		30.9
- Services (%)	37.3	46.2		65.9
Average distance to centroid	20.9	9.2		15.1
	ARG	AUT	.../...	CYP
	AUS	BEL	ROU	EST
	BRA	BGR	SVK	FRA
	BRN	CZE	SVN	GRC
	KHM	DNK	SWE	HKG
	CAN	FIN	CHE	IND
	CHL	DEU	TWN	IRL
	CHN	HUN	THA	LVA
	ICL	ISR	TUR	LUX
	IDN	ITA	USA	MLT
	MYS	JPN		PRT
	MEX	KOR		SGP
	NOR	LTU		ESP
	RUS	NLD		GBR
	SAU	NZL		
	ZAF	PHL		
	VTN	POL		

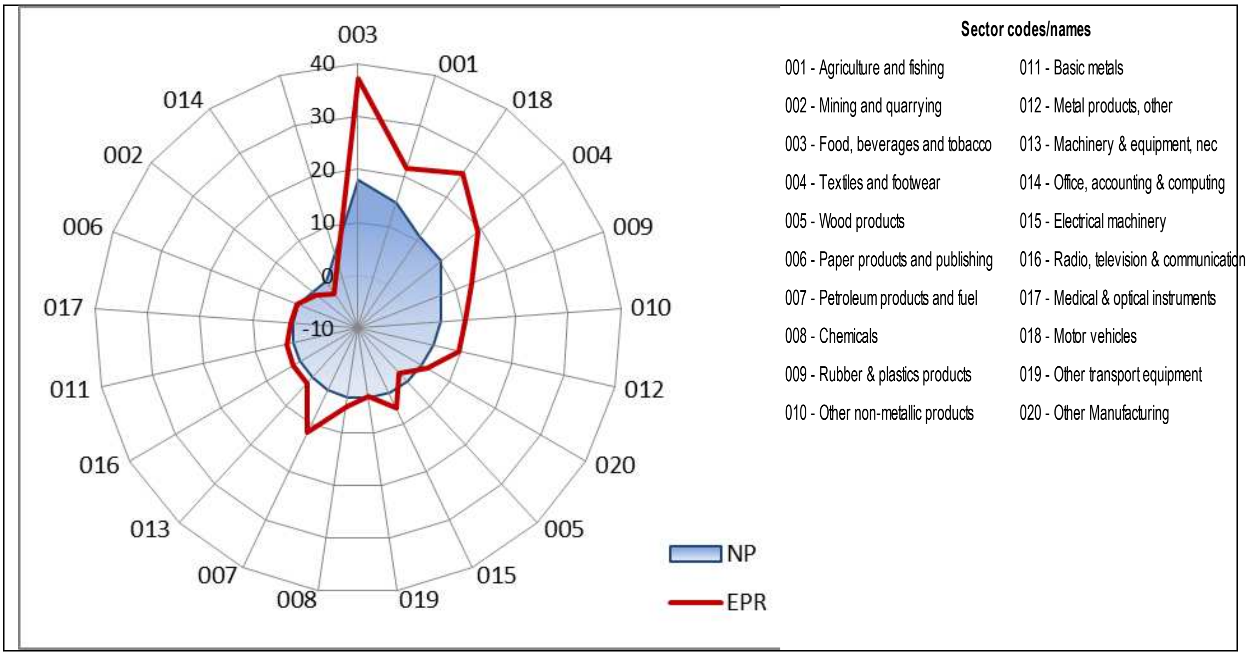
Note: K-Means clustering for illustrative purpose, imposing *a priori* the number of clusters to three. The sectoral share of domestic value-added corresponds to the centroid of the class.

This said, the cluster corresponding to the typical "manufacture oriented" economy is the most compact of the three, with an average distance to the centroid of only 9 despite a population of 26 elements. Natural resources oriented economies shows more variance (average distance of 21 for 17 members).

2.2 Nominal and Effective Protection

The highest nominal protection, in average of all countries covered by the *TiVA* database, is found in the sector producing food and beverage (003), followed by agriculture (001). Their effective protection rates are also high, especially for food and beverage. At the difference of agriculture, the primary sector of mining and quarrying (002) has almost zero nominal protection and a negative rate of effective protection (i.e., the additional cost paid on inputs is higher than the protection received on the inputs). The situation of manufacture products varies; automobiles (018) are usually highly protected, office and computing equipment (014) is the least protected of all sectors, suffering from a negative effective protection of -2%.

Figure 8 Average nominal and effective protections, 2008



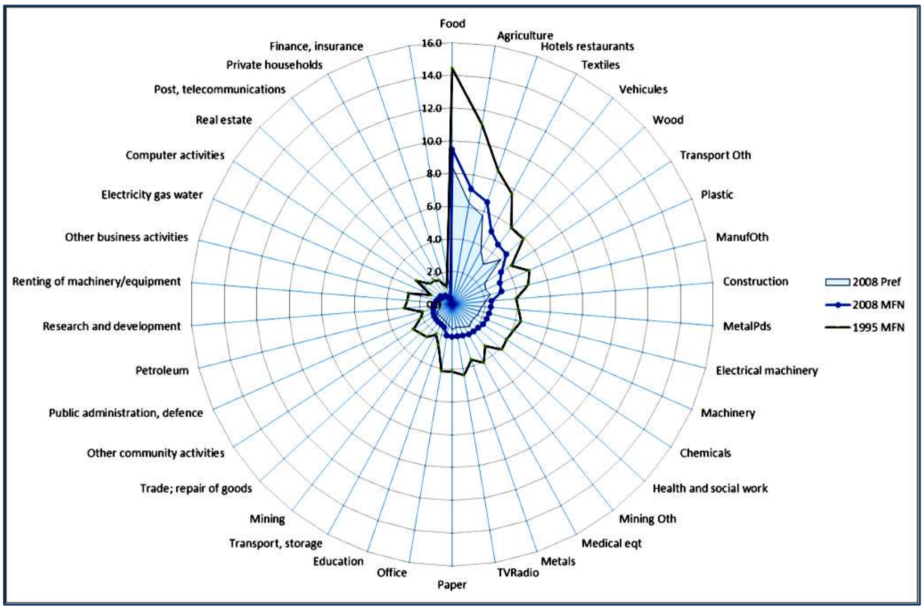
Note: Simple average of countries, on the basis of MFN applied tariffs.
Source: Based on Diakantoni and Escaith, 2014.

While tariff analysis usually exclude services (trade in services is not dutiable), the availability of input-output data allows extending the analysis of the additional cost of production created by duties to the tertiary sectors. Figure 9 presents the results obtained for all sectors and the impact of preferences (lower duties than the MFN treatment). Preferential tariffs are applied to the bilateral flows of inputs that are fully identified in an international input-output matrix.

When analysing the graph, it is important to remember that industries may purchase a large proportion of their inputs from suppliers that are classified in the same sector. Industries in the food and beverage sector, for example, will purchase raw agricultural inputs from agriculture and processed ones from other firms classified in the same food and beverage sector of activity. Because these two sectors benefits from high rates of nominal protection (Figure 8), the additional production cost will also be higher. Effective protection on services is by definition negative when nominal protection on goods is positive. This may lower the international competitiveness of the services industry when they are exporting directly. This will be, for example, the case of the tourist industry (hotels and restaurants) if the nominal protection on food and beverages is high, as in Figure 3 above. From a GVC trade perspective, the higher production cost resulting from tariffs imposed on inputs used by the services industry may also reduce the international competitiveness of exporting firms when the services-content imbedded in good production is high.
The reduction of nominal tariffs that followed the conclusion of the Uruguay Round (1995) induced a significant reduction in the additional production costs attributable to the indirect MFN taxation

on tradable inputs (Figure 9). The signature of preferential trade agreements has also reduced the production costs, in particular in the sectors of automobile and other transport equipment.

Figure 9 Additional production cost due to nominal tariff duties (1995-2008) and effect of preferences (2008)



Note: The data refers to the total cost of duties perceived on the inputs required for the production of one unit of output.
Source: Based on Diakantoni and Escaith, 2014.

3 EXPLORING LATENT PATTERNS

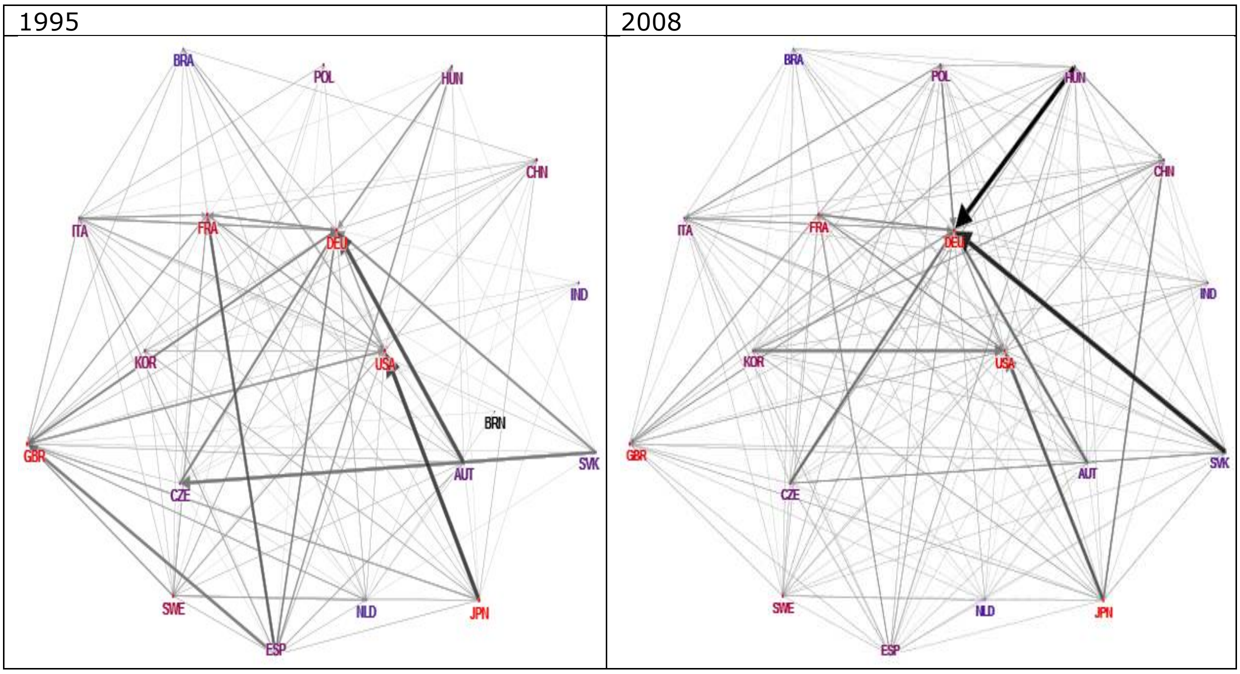
The section applies Exploratory Data Analysis (EDA) techniques to analyse more in details how the countries are positioned in relation to the set of economic, *TiVA* and trade policy indicators. EDA is a corpus of data mining techniques designed for the mapping and analysis of complex multi-dimensional datasets. It aims at extracting as much information as possible from the variance — variance being the essence of statistics.

3.1 From IO to Graph

International IO tables can be interpreted as an algebraic representation of a directed graph (Escaith, 2014). Graphs are also particularly useful for analysing international trade, if only for their (apparent) simplicity: they are simplified maps composed exclusively of vertices (nodes) and edges. Actual trade networks are best described as directed graphs, or digraphs, because they are made of directed edges or arcs (imports from, exports to) linking two trade partners (vertices or nodes); the trade value of each flow allows to weight the network. Despite their simplicity, they lead to relatively complex mathematical models, providing important insights on the way the trade partners interact. A series of indicators on the density of the relationship and the centrality of given nodes can be calculated. Those indicators are often similar to IO analytical indicators in their objective, yet they differ in their method. Network analysis has been a booming field of methodological and empirical research in the recent years, thanks in particular to the emergence of social networks. Applications on international trade can be found, *inter alios*, in Kam Ki Tang and Wagner (2010) or De Benedictis *et al.* (2013).

Figure 10 is an example built on trade flows in intermediate inputs produced by transport equipment industries. The graph shows the rise in the centrality of Germany as market of destination for parts and components for Europe, in particular for Eastern European countries. Japan is central as a producer of components that are exported for assembly in China (in 2008) or the USA (in both 1995 and 2008). The US market for exporting parts and components is also important for Korea in 2008, much more than in 1995. [19]

Figure 10 Bilateral export flows of intermediate goods from Transport Equipment sector, 1995-2008.



Note: Sectoral exports are expressed in percentage of total exports of goods and services from the producing economy perspective; for illustration purpose, only the most significant flows and the most significant nodes (based on eighencentrality) are showed in the graphs.
Source: Based on OECD-WTO *TiVA* database.

Actually, such an analysis could be done without an IIO table, by using traditional trade statistics and filtering for the relevant flows in intermediate products using the BEC. Nevertheless, using simultaneously IO analysis and network analysis can be complementary and shed important light on some points that may remain unclear using one methodology or the other. As we shall see in the next section, some features of network analysis have also some common points with exploratory data analysis.

3.2 Exploratory Data Analysis on TiVA, trade policy and economic characteristics

Two complementary EDA approaches (clustering and principal component analysis) are used here. The objective is to understand how the various economies that are covered by the OECD-WTO *TiVA* database can be classified according to their trade in value-added profile. Conversely, results can also be used for characterising the variables according to their association with the economic characteristics of the observations (countries). EDA is applied first to *TiVA* variables, then to trade policy. Most results are derived from Escaith and Gaudin (2014) and Diakantoni and Escaith (2014).

[19] Note that the sectoral flows are expressed here as a percentage of the total gross exports of a country; because the graph represents only the most significant flows, a partner country can remain of importance for the transport equipment but disappear from the graph in 2008 if the overall weight of the sectoral exports in the total has decreased from 1995 to 2008. Moreover, because the graph selected the node (countries) on the basis of their centrality or influence of a node in a network, some important bilateral relationship may not appear; for example, Mexico's exports to the USA are not reported, despite their economic importance, at the difference of Brazilian ones. This is explained by the high concentration of Mexican exports of transport equipment to the USA and her low interconnection with other nodes in the graph. More generally, the graphs presented here are just for illustration purpose and no analytical conclusion should be derived from such partial results.

3.2.1 In relation with TiVA variables

- ***Cluster analysis***

Escaith and Gaudin (2014) apply clustering analysis to the sample of countries included in the TiVA release of May 2013. [20] Using hierarchical clustering, the number of clusters was *a priori* set to 5 in order to have enough details.[21] Clustering results are always tentative and each one of the aggregative method has its strengths and weaknesses. We show here two methods (Complete Linkage and Ward's Linkage) to test the robustness of groups. [22] The within-class variance provides an indication on the compactness of each cluster but should be evaluated in relation to the number of objects belonging to the cluster.

Let's look first at the groupings produced by the Ward's method. Group 5, centered on Singapore, hosts small and open service-oriented economies. Group 4 include East-Asian developing economies, well inserted in international supply chains at the example of its most central 3 economy, Korea. Eastern European countries that conform group 3 are also well inserted in EU supply chains; the presence of Vietnam in this group being somewhat surprising as it shares little with them, besides having also been part of the Soviet bloc. Group 2 is very close to Group 3 and gathers most other European countries, plus Hong Kong and Israel (see Table 12). Group 1 is a rather loose cluster (within-class variance is at its highest) which includes all remaining countries. Rather surprisingly, European countries such as Austria and UK are included here, rather in in Group 2 (the presence of Norway, an European oil-exporting country, is more understandable).

Table 12 Hierarchical clustering of observations according to *TiVA* variables, 2008

Ward's method					
Class	1 (CAN)	2 (SWE)	3 (SVN)	4 (KOR)	5 (SGP)
Objects	17	21	8	4	3
Within-class variance	1267.43	584.83	375.96	612.24	821.34
	ARG	AUT	BGR	CHN	IRL
	AUS	BEL	CZE	KOR	LUX
	BRA	CHE	EST	THA	SGP
	CAN	CYP	HUN	TWN	
	CHL	DEU	MYS		
	GBR	DNK	SVK		
	IDN	ESP	SVN		
	IND	FIN	VNM		
	JPN	FRA			
	MEX	GRC			
	NOR	HKG			
	NZL	ISR			
	RUS	ITA			
	SAU	LTU			
	TUR	LVA			
	USA	NLD			
	ZAF	PHL			
		POL			
		PRT			
		ROU			
		SWE			

Complete linkages						
Class	1 (ESP)		2 (SVN)	3 (THA)	4 (IRL)	5 (SAU)
Objects	28		19	3	2	1
Within-class variance	930.16		472.70	859.02	1038.32	0.00
	ARG	IND	AUT	CHN	IRL	SAU
	AUS	ITA	BEL	IDN	LUX	
	BRA	JPN	BGR	THA		
	CAN	LVA	CZE			
	CHE	MEX	EST			
	CHL	NLD	FIN			
	CYP	NOR	HUN			
	DEU	NZL	ISR			
	DNK	POL	KOR			
	ESP	ROU	LTU			
	FRA	RUS	MYS			
	GBR	TUR	PHL			
	GRC	USA	PRT			
	HKG	ZAF	SGP			
			SVK			
			SVN			
			SWE			
			TWN			
			VNM			

Source: Escaith and Gaudin (2014)

But, as mentioned previously, this story-line is somewhat contingent to the choice of clustering method and any derived conclusion should focus on the most robust clusters. For example, clustering according to the complete linkage criteria partially reshuffles the cards. Only Ireland and

[20] Escaith and Gaudin (2014) use the "bottom up" variant of hierarchical clustering, at the first iteration, each observation makes its own cluster, then clusters are paired together on the basis of their proximity based on Euclidian distance in the p-dimensional variable space defined by the *TiVA* indicators; the level of aggregation increases as one moves up the hierarchy and the last iteration includes the whole sample.

[21] The optimal number of clusters defined on pure statistical grounds for was 4. We choose to keep the five clusters for illustrative purpose.

[22] Complete linkage, a hierarchical clustering method similar to average linkage, is less susceptible to be affected by random noise and the presence of outliers, but it can unnecessarily break large clusters as it favors compact shapes. Ward's agglomerative hierarchical clustering procedure method attempts to minimize the sum of the square distances of points from their cluster centroid and favours dense clusters.

Luxembourg and, to a lesser extent, China and Thailand, keep on projecting a clear identity on their cluster. Saudi Arabia, which was before associated with other natural resources rich countries such as Russia or South Africa, appears now as a clear outlier. The two largest groups (1 and 2) are rather fuzzy and amorphous. Another method (average linkage, not shown here) would point to three distinct groups on the extremes sides of the hierarchical dendrogram (commodity exporters, manufacture exporters and small open economies). These groups have the lowest within-class variance. In contrast, a fuzzier group (Cyprus, Denmark, Greece, Japan, USA, Vietnam) stands in the middle of the spectrum but close to the group 3 of service oriented "post-industrial" economies. The outlier corresponds to commodity-rich Saudi Arabia.

To sum up the results obtained in Escaith and Gaudin (2014), the hierarchical clustering according to TiVA variables reveals a contrast between countries whose *TiVA* pattern is well identified and the others. The formers find themselves in the same group whatever the method employed, whereas the classification of the latter depends on the type of hierarchical clustering. Among the well-identified TiVA patterns, are the one at the extremes sides of the T_DT spectrum (i) manufacturing economies, (ii) primary good producers (Saudi Arabia being an outlier, even for this group), and (iii) small open economies. For countries presenting mixed features (diversified emerging countries) or service oriented larger economies, the classification into one of these identified patterns depends on the method employed.

- ***Principal Component Analysis***

Principal Component Analysis (PCA) is applied with the aim of visualising the relationship between *TiVA* indicators and the economic characteristics of the countries. A series of a priori relevant economic indicators were collected for each of the country included in the TiVA database. Those variables describe the economic structure of the trade reporters and their partners (GDP and its composition, per capita income, intensity of R&D; incidence of foreign direct investment, etc.) and are sourced mainly from the World Bank (World Development Indicators for year 2008). The *TiVA* variables were added as supplementary variables to the PCA; supplementary variables do not interfere with the calculation of principal components but their projection on the resulting variable space shows how these *TiVA* variables position themselves in relation to the active variables. In order to simplify the graph, only the most aggregated *TiVA* variables (foreign and domestic value-added in total exports, by sectoral origin) were inserted in the calculation.

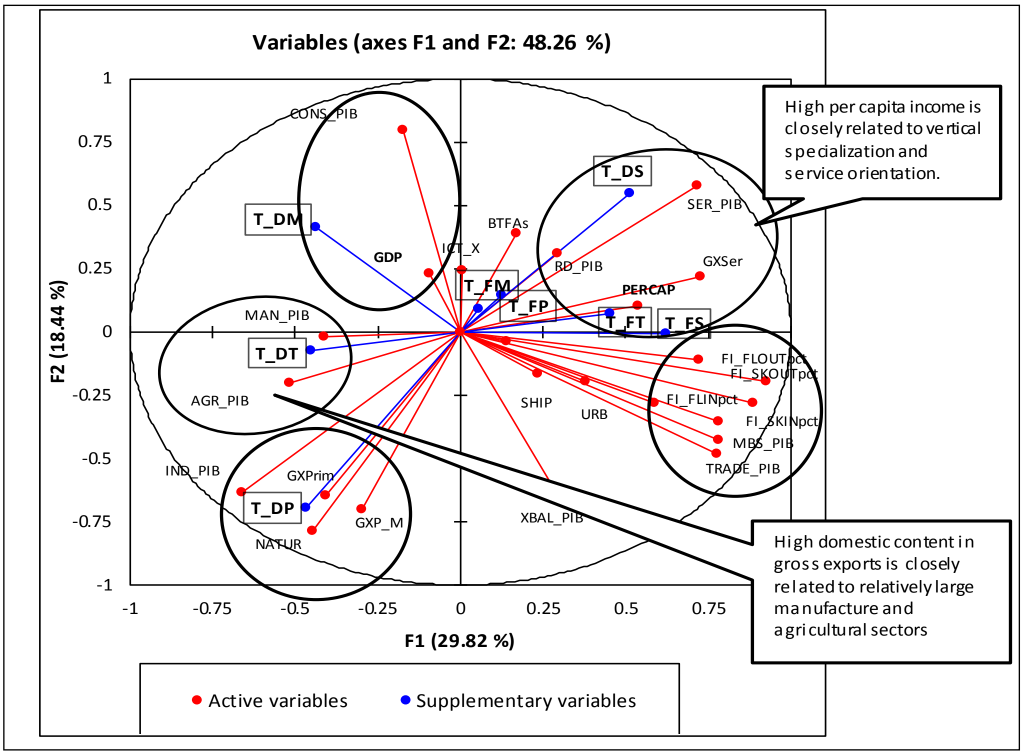
Figure 11 below shows the results obtained with structural economic variables. The active economic variables cluster the observations according to their openness to trade and to foreign direct investment, as well as their export specialization (ie, services vs. natural resources). On the right side of the horizontal axis (explaining 30% of total variance in the active variable space), we find trade related indicators: ratio trade over GDP, incidence of FDI stock and flow.

The way supplementary *TiVA* variables are projected on the new space defined by the principal component provides information on their association with the most relevant characteristics. Vertical specialization variables T_FS and T_FT (services and total foreign content in total exports) tend to be associated with the right-side of the horizontal axis (high ratio of trade over GDP, strong incidence of FDI). They are also in the neighbourhood of the high per capita income variable. Moving towards the North-East, we observe that the domestic content of services VA in total exports (T_DS) is closely related to the weight of services in GDP.

Conversely (South-West quadrant) and as expected, domestic primary sector content in total exports is related to natural resources endowment, the ratio of primary exports over manufacture exports and the weight of good-producing (non-services) sectors in the economy. This area of the graph is rather dissociated from high per capita income. Domestic manufacture content in total exports is more closely related to the ratio consumption/GDP (North-West quadrant) and large economies measured by their GDP. Nevertheless, the influence of economic size as an influential variable is quite limited, as can be inferred from the rather centric position of the GDP variable on the graph. [23]

[23]

Figure 11 *TiVA* variables as supplement to a principal component analysis on structural variables, 2008



Note: PCA reduces a p-multiple dimensional space (p: number of initial active variables) to a lower dimensional space, while preserving as much information (or variance) as possible. Here, the first two principal components capture 48% of total variance. For a description of variable codes, see Annex.
Source: Adapted from Escaith and Gaudin (2014).

3.2.2 In relation with trade policy variables

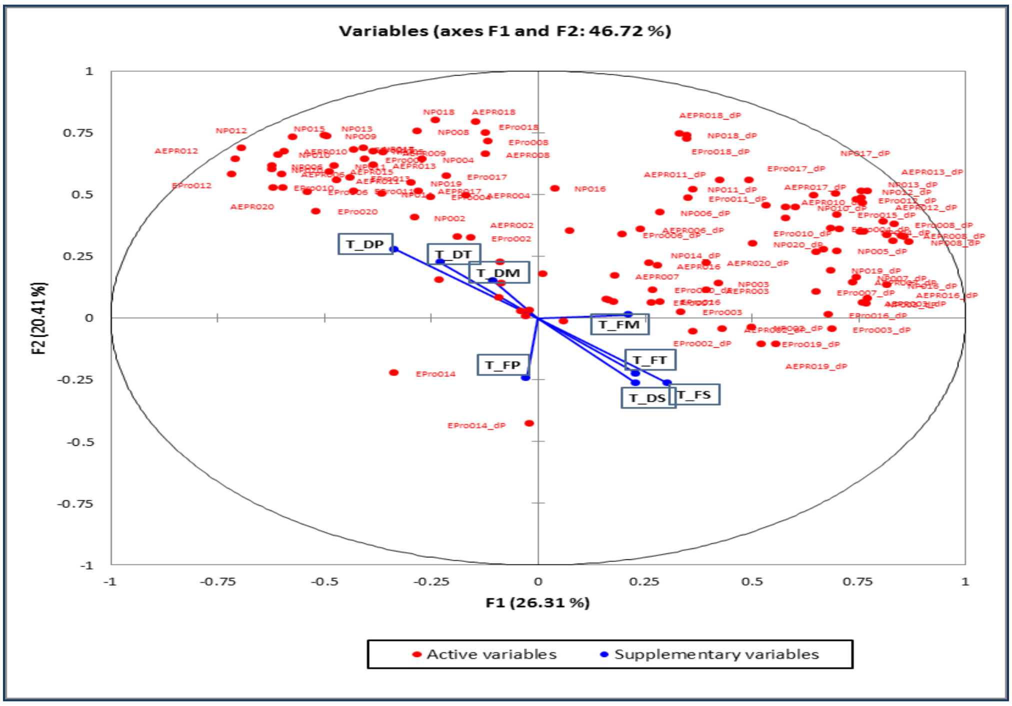
- ***Principal Component Analysis***

The interpretation of the PCA projecting *TiVA* on trade policy variables (Figure 12) is rather straightforward. The graph of active variables is organized between a North-West side quadrant of high nominal and effective protection variables and an East side dominated by the effect of preferential trade agreements.

As becomes clearer when projecting the countries on the graph (Figure 13), the results are clearly dominated by the effect of European economies (remember that all EU members share the same external nominal tariff schedule). These countries form a compact cluster on the left-hand side. Only Mexico, far away in the North-East quadrant, joins this group of countries strongly influenced by the impact of preferential agreements on their trade policies. Other economies are scattered on the left-hand side. In the North-East quadrant tend to predominate natural-resources rich countries, but there are exceptions (Australia or Norway are on the Southern side of the graph). Norway, in particular, is an interesting case as it stays close to services-oriented Asian economies like Hong-Kong and Singapore despite being a natural-resources rich country. Another peculiar case is Belgium, who appears very distinct from the other EU members. This may look illogic as Belgium applies the same nominal tariff schedule than other EU members; the difference here is entirely due to her specificities in the input-output coefficients that affect effective protection. [24]

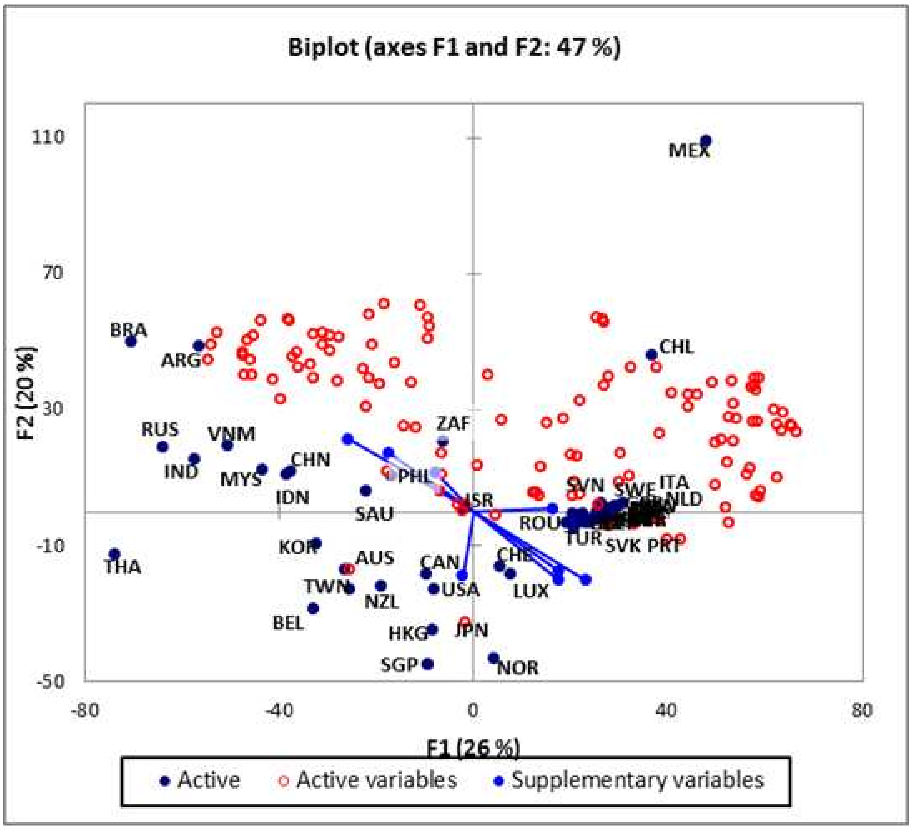
[24] Belgium often appears as an outlier (compared to the rest of the EU) for the low incidence of domestic value-added in the exports of natural resources-based products..

Figure 12 *TiVA* variables as supplement to a principal component analysis on trade policy variables, 2008



Source: Based on Diakantoni and Escaith (2014), and Escaith and Gaudin (2014).

Figure 13 Projection of countries and supplementary *TiVA* variables on the principal components defined by trade policy variables, 2008

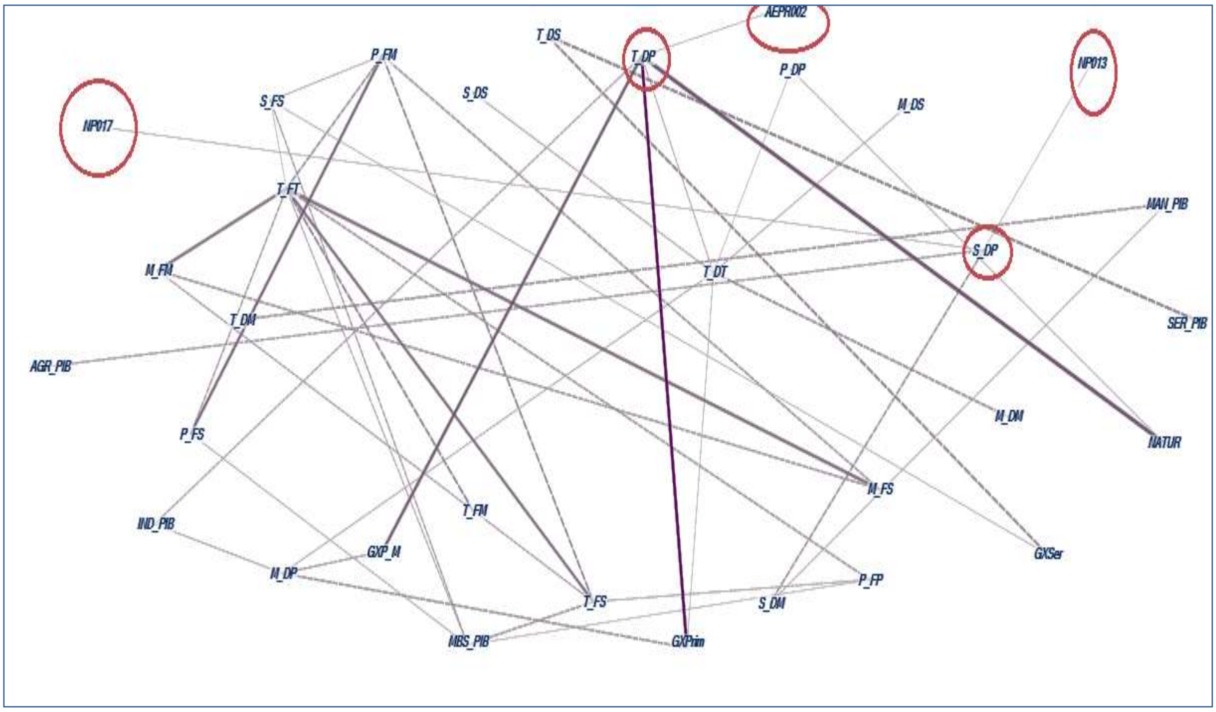


Source: Based on Diakantoni and Escaith (2014), and Escaith and Gaudin (2014).

- ***Network Analysis***

The next section looks at similarities between variables using the tools derived from graph and network theories. The graph is based on the matrix of Euclidian distances between variables which is built as the first step of a hierarchical clustering exercise and transforming these distances into similarity indexes. [25] The resulting graph is simplified by showing only the strongest linkages.

Figure 14 Graph analysis of the similarities among TiVA, economic and tariff variable spaces *(main relationships)*



Note: Highlighted in red are the associations with tariff variables. This graph is for illustrative purpose only.
Sources: See Annex

Only three tariff policy variables are significantly associated with TiVA or economic variables when looking at a simplified graph of similarities between all variables spaces (TiVA, economics and tariff policy). [26] All three are related to the role of domestic value-added from primary sector in exports:

(i) High effective protection on sector 002 (Mining and quarrying) and high nominal protection on sector 017 (Medical, precision & optical instruments) are related to the primary domestic content in gross total exports (T_DP);
(ii) high nominal protection on sector 013 (Machinery & equipment, nec) is more specifically related to the primary domestic content embodied in gross services exports (S_DP).

Actually, the high protection received on manufacture sectors does not correspond to a strong industrial orientation. Both T_DP and (but in a lesser extent) S_DP are themselves related to the natural resources endowment of the economy. S_DP is more related to the agricultural orientation of the domestic economy while T_DP has a much richer interrelation with exports of primary goods (GXPim and GXP_M) and the role of primary value-added in the country's manufacture production and exports (IND_PIB and M_DP). Therefore, if those high protections were set in the past to foster the development of a national industry in those sectors, the results in 2008 are less than convincing.

[25] The graph is build using the Fruchterman-Reingold method, based on force-directed algorithms with a relatively high repulsive coefficient in order to separate nodes that are poorly related. High repulsive parameters tend to produce globular sub-graphs and are analogically similar to the joint minimization of within-cluster distance and maximization of between-cluster distance of K-Mean clustering.

[26] A more detailed graph, less demanding in terms of associativity, would show more interactions with tariff variables: those are the most significant ones.

4 CONCLUSIONS

The *TiVA* database developed by OECD and WTO links intermediary trade flows with national accounts data to construct international input-output tables and measure the value-added content of trade. As we have seen, *TiVA* is much more than a database because it allows deploying the full strength of input-output analysis to investigate forward and backward linkages in an international context. The close relationship between input-output models and graph theory allows also benefiting from the recent advances in network analysis. Implications for macroeconomic coordination are also straightforward. Measuring the home-country value-added content absorbed in the final demand of trade partners allows to understand better the correlation of business cycles: even if no direct trade takes place with a third country, a macroeconomic recession in this country may affect indirectly home-country exports of intermediate goods through the global value chains.

Trade in value-added reveals the importance of intermediate goods representing more than half of international transactions volume. Transaction costs (border and behind the border cost of trade) are a crucial part of the competitiveness of firms and determine in part their ability to participate in production networks. The results obtained by crossing trade value-added indicators derived from the *TiVA* database with tariff data (Diakantoni and Escaith, 2014) allowed to construct effective protection indicator; identifying the source of intermediate inputs by trade partners provided additional information on the impact of preferential trade agreements. With parts and components crossing many national borders before the final goods reach the consumers, tariffs have an accumulative effect on production costs. Moreover, measuring trade in value-added highlights the importance of services in international trade and underlines their role in determining international competitiveness. Indirectly, services producers pay customs duties when purchasing intermediates required for their functioning. They face higher production cost but do no benefit from nominal protection; their EPRs are negative and their external competitiveness is reduced.

Finally, by combining the value-added and the trade policy datasets with indicators representative of the level of economic development, resources endowment and other structural variables, we obtained a multi-dimensional data-cube packing a rich informational content. This data-cube was analysed using exploratory data analysis techniques, in order to highlight underlying patterns and profiles. The trade profile of the various economies in terms of their value-added composition reproduces a series of characteristics that still reflect the traditional comparative advantages of each country and its level of development, besides reflecting their openness to international trade. Natural resources endowments, on the one hand, and services orientation, on the other one, are among the most determinant variables for defining *TiVA* clusters. A more detailed analysis of the countries according (Escaith and Gaudin, 2014) would show that once their predominant merchandise export category (whether commodities or manufacture) is taken into consideration, similar *TiVA* profiles can coexist with different development levels. However this is not true for service exporters, which tend to be more homogeneous from an economic perspective. Thus, direct and indirect VA exports of services are a marker of the level of economic development and remain a crucial determinant of the TiVA profile.

The present essay presents only a small part of the analytical potential derived from input-output and graph analysis. Because comparable global data have been available only very recently (2012 for the WIOD project; 2013 for the OECD-WTO *TiVA*) the empirical literature derived from these trade in value-added datasets is still incipient. We have so far scrapped only the surface of the issue. Having this information is already a great step in the right direction and helped demonstrating that understanding the economic relevance of trade in today's globalised economy required new instruments and new methodologies. The results capture the big picture, resizing the relative weight of services and manufacture or the real size of bilateral trade imbalances. Trade in value-added helps also apprehending the direct and indirect impacts of tariff policy on the effective rate of protection received by industrial sectors and the additional costs supported by services.

The existing indicators on trade in value-added still suffer from serious shortcomings. While they bring very valuable information on the relationship between international trade and economic development, available databases developed on official data still need to be extended in order to cover all developing and least developed countries. The present trend is to base *TiVA* estimates on

Supply and Use Tables rather than national input-output tables; this simplification opens the way for the incorporation of more countries and a more frequent update of the official datasets.

The main weakness so far from a trade-analysis perspective is the high degree of aggregation of the sectoral data. Trade analysts are used to work at very detailed levels of the Harmonized System (HS6 digit or more) when analysing the impact of tariff and non-tariff measures. When calculating the Effective Protection Rates that are analysed in the paper, the first step was to aggregate the tariff data in order to match the input-output sectoral classification. A lot of valuable information was lost in the process.

Moreover, the new theoretical models on international trade put a lot of emphasis on firm heterogeneity (Escaith, 2014). Firms that are active on the international market are often larger and technologically more advanced than firms producing only for domestic use. In addition, exporting firms tend to make a more intensive use of imported inputs, especially in developing countries. All those characteristics have important implications and may lead to large aggregation bias if not taken into account. The new frontier for trade statisticians lays therefore in (i) the development of micro-database to fully capture the heterogeneity of firms that are active in these global value chains and (ii) incorporate the heterogeneity into the input-output models in order to capture this heterogeneity, for example by differentiating firms by size or by their export-orientation (often leading to the same sub-sets).

Thanks to the excellent reception of the new datasets and the support received from the G-20 in 2012, the research programme on global value-chains is now firmly rooted into the work programme of international statistics. A recent initiative by the UN Statistical Commission to develop international recommendations for developing new indicators on International Trade and Economic Globalization based on the global value chain concepts is a significant step forwards in this direction.

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6 ANNEX: VARIABLES UTILISED IN THE ANALYSIS: CODES AND DESCRIPTION

TiVA indicators are in Table 7, the list of economies included in the study is in Table 8 and the industrial sectors in Figure 8.

Table 13 Dictionary of variables utilised in the analysis.

Indicator description	Indicator code	Source
Agriculture, value added (% of GDP)	AGR_PIB	WDI, World Bank
Final consumption expenditure, etc. (% of GDP)	CONS_PIB	WDI, World Bank
High-technology exports (% of manufactured exports)	HITEC_X	WDI, World Bank
ICT service exports (% of service exports, BoP)	ICT_X	WDI, World Bank
Industry, value added (% of GDP)	IND_PIB	WDI, World Bank
Manufacturing, value added (% of GDP)	MAN_PIB	WDI, World Bank
Imports of goods and services (% of GDP)	MBS_PIB	WDI, World Bank
GDP per capita (current US$)	PERCAP	WDI, World Bank
Research and development expenditure (% of GDP)	RD_PIB	WDI, World Bank
Services, etc., value added (% of GDP)	SER_PIB	WDI, World Bank
Trade (% of GDP)	TRADE_PIB	WDI, World Bank
External balance on goods and services (% of GDP)	XBAL_PIB	WDI, World Bank
Exports of goods and services (% of GDP)	XBS_PIB	WDI, World Bank
GDP (current US$)	GDP	WDI, World Bank
Liner shipping connectivity index (maximum value in 2004 = 100)	SHIP	WDI, World Bank
Population in urban agglomerations of more than 1 million (% of total population)	URB	WDI, World Bank
Total natural resources rents (% of GDP)	NATUR	WDI, World Bank
Labor participation rate, total (% of total population ages 15+)	LAB_PART	WDI, World Bank
Agricultural land (% of land area)	AGR_LAND	WDI, World Bank
Cost to export (US$ per container)	COS_EXP	WDI, World Bank
Cost to import (US$ per container)	COS_IMP	WDI, World Bank
Current account balance (% of GDP)	CA_BAL	WDI, World Bank
Employment in agriculture (% of total employment)	AGR_EMP	WDI, World Bank

Employment in industry (% of total employment)	IND_EMP	WDI, World Bank
Employment in services (% of total employment)	SER_EMP	WDI, World Bank
Employment to population ratio, 15+, total (%)	EMP_POP	WDI, World Bank
Gross national expenditure (% of GDP)	GRO_EXP	WDI, World Bank
Gross savings (% of GDP)	GRO_SAV	WDI, World Bank
Inflation, consumer prices (annual %)	INF_CPI	WDI, World Bank
International tourism, receipts (% of total exports)	INT_TOUR	WDI, World Bank
Internet users (per 100 people)	INT_USER	WDI, World Bank
Labor force participation rate, total (% of total population ages 15-64)	LAB1564	WDI, World Bank
Labor force with tertiary education (% of total)	EDUC_TER	WDI, World Bank
Land area (sq. km)	LAND	WDI, World Bank
New businesses registered (number)	NEWBIZ	WDI, World Bank
Oil rents (% of GDP)	OIL	WDI, World Bank
Passenger cars (per 1,000 people)	PAS_CAR	WDI, World Bank
Population ages 15-64 (% of total)	AGE_WORK	WDI, World Bank
Population, total	POP	WDI, World Bank
Public spending on education, total (% of GDP)	SPE_EDUC	WDI, World Bank
Rural population (% of total population)	RURAL	WDI, World Bank
Time required to start a business (days)	TIMBIZ	WDI, World Bank
Time to export (days)	TIM_EXP	WDI, World Bank
Number of Free Trade Agreements enforced	BTFAs	De Sousa.[27]
Foreign Direct Iinvestment, Inward Stock (USD Million)	FDI_SK_IN	UNCTAD
FDI Outward Stock (USD Million)	FDI_SK_OUT	UNCTAD
FDI Inward Flow (USD Million)	FDI_FL_IN	UNCTAD
FDI Outward Flow (USD Million)	FDI_FL_OUT	UNCTAD
FDI Inward Stock (percent GDP)	FI_SKINpct	UNCTAD
FDI Outward Stock (percent GDP)	FI_SKOUTpct	UNCTAD
FDI Inward Flow (percent GDP)	FI_FLINpct	UNCTAD
FDI Outward Flow (percent GDP)	FI_FLOUTpct	UNCTAD
Primary exports (Gross, % total)	GXPrim	*TiVA*
Manufacture exports (Gross, % total)	GXMan	*TiVA*
Services exports (Gross, % total)	GXSer	*TiVA*
Ratio Primary Exports / Manufacture Exports (Gross, %)	GXP_M	*TiVA*
Manufacture export, % domestic Value-Added from Manufacture	M_DM	*TiVA*
Manufacture export, % domestic VA from Primary	M_DP	*TiVA*
Manufacture export, % domestic VA from Services	M_DS	*TiVA*
Manufacture export, % foreign VA from Manufacture	M_FM	*TiVA*
Manufacture export, % foreign VA from Primary	M_FP	*TiVA*
Manufacture export, % foreign VA from Services	M_FS	*TiVA*
Primary export, % domestic VA from Manufacture	P_DM	*TiVA*
Primary export, % domestic VA from Primary	P_DP	*TiVA*
Primary export, % domestic VA from Services	P_DS	*TiVA*
Primary export, % foreign VA from Manufacture	P_FM	*TiVA*
Primary export, % foreign VA from Primary	P_FP	*TiVA*
Primary export, % foreign VA from Services	P_FS	*TiVA*
Services export, % domestic VA from Manufacture	S_DM	*TiVA*
Services export, % domestic VA from Primary	S_DP	*TiVA*
Services export, % domestic VA from Services	S_DS	*TiVA*
Services export, % foreign VA from Manufacture	S_FM	*TiVA*
Services export, % foreign VA from Primary	S_FP	*TiVA*
Services export, % foreign VA from Services	S_FS	*TiVA*
Total export, % domestic VA from Manufacture	T_DM	*TiVA*
Total export, % domestic VA from Primary	T_DP	*TiVA*
Total export, % domestic VA from Services	T_DS	*TiVA*
Total export, total % domestic VA from all sectors	T_DT	*TiVA*
Total export, % foreign VA from Manufacture	T_FM	*TiVA*
Total export, % foreign VA from Primary	T_FP	*TiVA*
Total export, % foreign VA from Services	T_FS	*TiVA*
Total export, total % foreign VA from all sectors	T_FT	*TiVA*
Nominal Protection at Most Favoured Nation, including Ad Valorem Equivalents, for each good producing sector of *TiVA*	NP	WTO IDB
Effective Protection Rate (including AVEs), for each good producing sector of *TiVA*	EPro	WTO IDB
Absolute Effective Protection (numerator of the EPR, including AVEs), for each good producing sector of *TiVA*	AEPR	WTO IDB
Difference between "NP at MFN" and "NP including preferences", for each good producing sector of *TiVA* (here, sector 001)	NP001_dP	WTO IDB
Difference between Effective Protection Rate at MFN and including preferences (here, sector 002)	EPro002_dP	WTO IDB
Difference between Absolute Effective Protection at MFN and including preferences (here, sector 003)	AEPR003_dP	WTO IDB

[27] De Sousa, José(2012), pages 917-920.