Value Added Trade Restrictiveness Indexes. Measuring Protection with Global Value Chains

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Abstract

In this work we build on Anderson and Neary (1996; 2005)insight and extend the set of 'trade restrictiveness indexes' in order to account for the rising of the international fragmentation of production in Global Value Chains. This is done by incorporating the factor content approach of Neary and Schweinberger (1986) into a behavioral model of tariff aggregation, and extending it to a value-added framework. We define the reference criteria for the equivalent impact of trade policies using the decomposition methods proposed in macro approaches by recent value added in trade literature. The index is construct in such a way to distinguish, at the bilateral level, the domestic and the foreign (bilateral or indirect) value added content in the importing country. In our comparative static analysis, we adapt and extend the code and data of a newly developed version of the GTAP model with sourcing of imports by agent, in order to implement the value added decomposition of trade flows. The overall protectionist stance is then measured in terms of value added rather than with reference to the more traditional metrics, such as gross trade.

Keywords: Computable General Equilibrium (CGE), Global Trade Analysis Project (GTAP), Global Value Chains (GVCs), Inter-Country Input-Output (ICIO), Trade policies, Trade Restrictiveness Indexes (TRI), Value added trade.

1. Introduction

International economists have long been concerned with empirical assessment of trade policy restrictiveness. The topic is still relevant after more than half a century of efforts to multilaterally or regionally liberalize trade. Recent developments in the international division of labour (Daudin et al., 2011) - emerged from what Baldwin (2006) labels globalization 2nd unbundling - have lead countries to be increasingly involved in *task trade* (Grossman and Rossi-Hansberg, 2008) in which value is added at various steps performed in different locations. Traded intermediates pass through global value chains (GVCs) and cross borders multiple times, directly implying that even small levels of tariffs, if cumulatively repeated, matter (Yi, 2003 and 2010; Koopman et al., 2010; Rouzet and Miroudot, 2013).

To develop summary statistics of trade protection, the first challenge is to define a proper method of aggregating across different policy instruments over thousands of commodities. While the issue of *how trade restrictiveness should be measured* is still a controversial one (Krishna, 2009) - as the existence of a variety of indexes of protection witnesses[1] - a theoretical foundation has been given trough the work of Anderson and Neary (1996; 2003), which lays the intellectual foundations for the development of index numbers for policy variables that maintain the link between the aggregated information and the economic variable in which the interest lies.

Building on this insight, we set a new framework for trade restrictiveness indexes in order to account for the rising of the international fragmentation of production in GVCs. This allows to reckon with the symbiotic relationship emerged between exports and imports, which implies that mercantilist-styled *beggar thy neighbour* strategies can turn out to be *beggar thyself*' miscalculations (IMF, 2013; Miroudot and Yamano, 2013). If production processes are interconnected in chains involving many countries, restrictive measures mostly impact domestic firms exporting intermediate inputs processed abroad and then imported back[2]. Moreover, tariffs applied to the direct partner have indirect effects on third countries supplying inputs which are embodied in bilateral flows. In evaluating the repercussions of trade policies it is then required to depart from gross measurement of trade and identify the origin of value added - or equivalently of primary factor inputs - in trade flows.

Several methods for the decomposition of gross trade have been proposed starting from the pioneering work of Hummels, Ishii, and Yi (2001) and with a large number of recent contributions (Daudin et al., 2011; Stehrer et al., 2012; Johnson and Noguera, 2012; Los et al., 2013, 2015; Wang et al., 2013; Koopman, Wang, Wei, 2014; Lejour et al., 2014; Cappariello and Felettigh, 2015; Borin and Mancini, 2015). Rooted in Leontief (1936), these efforts - at different degrees of sophistication - bring "new trade numbers" (Baldwin and Robert-Nicoud,

[1] For a discussion of tariff aggregation methods proposed in the literature, see Cipollina and Salvatici (2008).
2 This effect adds to the direct impact that an increase in import costs has on domestic firms processing imported inputs for exports, whose competitiveness crucially depends on their ability to source inputs cheaply (OECD 2013).

2014) replacing gross statistics, allowing a more accurate analysis of trade. We make use of these instruments from a value added in trade perspective[3], applied to the bilateral level, redefining the reference criterion for the equivalent impact of trade policies. This is done by incorporating the factor content approach of Neary and Schweinberger (1986) into a behavioral model of tariff aggregation, and extending it to a value-added framework. The extended model is used to define three different benchmarks against which to measure restrictiveness, accordingly to where the value added originates. The resulting indexes are equivalent to the actual trade policies in terms of the chosen impact, namely on domestic or foreign (bilateral or multilateral) value added.

In the next section we briefly discuss the existing literature linking trade policies measurement and the GVCs analysis. The third section sets up the model underlying the definition of the index. In the fourth section we adapt and extend the code of a newly developed version of the GTAP model with sourcing of imports by agent (Walmsley et al., 2014; Public Procurement Project) in order to implement the value added decomposition of trade flows. In the fifth section we present the results and conclude.

2. The Existing Literature

GVCs concerns are vibrant in policy discussion and have gained prominence in the research agendas of the major international organizations[4]. The WTO and the OECD launched the "Made in the World Initiative" in 2011 and Baldwin (2014) asks for a WTO 2.0 to adapt world trade governance to the realities of supply-chain trade. Jointly, efforts in developing data and statistics are flourished and new global databases tracing out transactions, both within and between countries, in intermediate and final flows at the sector level, have been elaborated, including, OECD/WTO-TiVA (Yamano and Ahmad, 2006; OECD-WTO concept note, 2012), WIOD (Dietzenbacher et al., 2013; Timmer et al., 2015), GTAP-MRIO (Narayanan et al., 2012; Johnson and Noguera, 2012; Wamsley et al., 2014), GTAP-ICIO (Koopman et al, 2010).[5]

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[3] We use a "value added in trade" approach since our interest is on decomposing value-added by source in a country's trade flows, that is we give a measure of the value added embodied in imports (Daudin et al., 2011; Stehrer et al., 2012; Foster-McGregor and Stehrer, 2013; Amador and Stehrer, 2014). This is fully consistent with the factor content literature starting from Reimer (2006; 2011) and Trefler and Zhu (2010), built on the seminal contribution of Vanek (1968). A slightly different concept is that of "trade in value added", in which the focus is on computing the origin country's value-added induced by a destination country's consumption (Johnson and Noguera, 2012; Los et al., 2013, 2015; Koopman et al., 2014; Wang et al., 2014; Lejour et al., 2014; Cappariello and Felettigh, 2015). For a comparison of the two measures of value added flows, see Stehrer (2012).

4 See, for example, OECD and WTO (2012), OECD (2013), IMF (2013), UNCTAD (2013; 2015), OECD, WTO, and WB (2014).

[5] Different analytical purposes within the framework of GVCs are behind this data development linking national input-output tables with trade data, such as the assessment of the foreign content of domestic production (Feenstra, and Hanson, 1996), the measurement of vertical specialization (Hummels et al., 2001; Daudin et al., 2011), the comparison between gross and value-added trade (Johnson and Noguera, 2012; Stehrer et al., 2012; Koopman et al., 2014).

Yet, in theoretical and empirical analysis of trade policy the analytical consequences of an internationally fragmented organization of production processes are barely considered. The few exceptions are mainly linked to the theory of tariff escalation and effective protection, in which the tariff levels on both primary inputs and final output are considered. Let i and j index sectors, the effective rate of protection (ERP) is expressed as the proportional change in the price of value added due to the tariff structure (Leith, 1968)[6]:

$$ERP_j = \frac{t_j - \sum_i (t_i * a_{ij})}{1 - \sum_i a_{ij}}$$

where t_j is the nominal protection on imports of sector j, $\sum_i (t_i * a_{ij})$ is the weighted average of tariffs paid on the required inputs, and a_{ij} are the elements of the matrix $A$of technical coefficientsgiving intermediate consumption of i by $j$over j total output.

Yet, the split of production processes in many steps, performed among different countries, and the consequential huge growth of intermediate trade, imply that a traded input could be repeatedly used at different stage of processing, before the final good is produced. The original ERP formulation considers only two steps of production (imported input *directly* used to produce output), and turns out to be inconsistent with the recent changes in patterns of global trade. Diakantoni and Escaith (2012) use Leontief insight and the four dimensional information given by international input-output matrices (country/sector of origin/destination) to refine the specification of the ERP, incorporating the *indirect* consumption of intermediate inputs. Via the substitution of technical with Leontief coefficients, the total amount of output cumulatively (directly and *indirectly*) required to produce for consumption is taken into account into the ERP equation[7]:

$$ERP_j^r = \frac{t_j^{wr} - \sum_{i,s} t_i^{sr} * l_{ij}^{sr}}{1 - \sum_{i,s} l_{ij}^{sr}}$$

where l_{ij}^{sr} is an element of the Leontief inverse matrix, giving the total amount of the gross output of sector *i* in country *s* required for a unitary increase in consumption of sector *j*'s final goods in *r*. To get the intuition behind the Leontief inverse one can expresses it as a converging geometric series having A as the common ratio: $(I - A)^{-1} = (I + A + A^2 + A^3 +$

6 A different definition of the effective rate of protection is that of Corden-Anderson and Naya as the share by which the protection increases the remuneration of factors of production (value added) when compared to value added under free trade (Balassa, 1965; Corden, 1966; Anderson and Naya, 1969):

$$ERP_j = \frac{V_j - V_j^*}{V_j^*},$$

where, V_j is the value added per unit of output under protection, and $V_j^*$is the value added under free trade.

7 The subscripts denote sectors while superscripts refer to countries.

...), summing all rounds of intermediate required for a unitary increase of the output starting from direct effect (I) and going on in successive orders (A^2, A^3 ...)[8].

Chen et al. (2013) follow the way of incorporating multiple stage of production relaxing, simultaneously, the small country assumption of the traditional ERP introducing an incomplete tariff pass-through to domestic producers, which is approximated as $\left(\frac{\mathcal{E}}{\mathcal{E}+\sigma}\right)t$, where $\mathcal{E}_j$ is the estimated export supply elasticity for goods produced in sector j, and σ_j is the import demand elasticity in the same sector. Accordingly, the "new" ERP is defined as:

$$NERP_j = \frac{\left(\frac{\mathcal{E}_j}{\mathcal{E}_j+\sigma_j}\right)t_j - \sum_i (t_i * l_{ij})\left(\frac{\mathcal{E}_i}{\mathcal{E}_i+\sigma_i}\right)}{1-\sum_i l_{ij}}$$

Applying the index to China, they illustrate the inherent biases deriving from the conventional assumptions in the ERP estimation, finding low (and even *trivial*) degree of actual protection due to Chinese import tariffs in many sectors in the period 1992-2010)[9].

These refinements in the definition of the effective protection are of interest when the *level* of trade protection is measured in the presence of GVCs. Yet, they do not consider any potential endogeneity between the level of tariffs and the input intensity, that is, for a prohibitive tariff inputs are not imported and they do not enter in the computation of effective protection. A counter-factual approach, based on estimated rather than observed coefficients should solve this problem. In add, trade policies have multiple effects and the lack of a theoretical foundation, which characterizes the outcome measures (such as the ERP), causes them to not be useful in giving reliable indications about distortional effects on macroeconomics variables due to protectionism (Anderson, 2003; Cipollina and Salvatici, 2008; Anderson et al., 2013). We follow the approach developed by Anderson and Neary (1994) in using a behavioral model of tariff aggregation, in order to define weights *representing the effects of the tariffs according to a fundamental economic structure* (Cipollina and Salvatici, 2008). The index is constructed depending on the specific dimension

[8]To understand the mechanism underlying the formula, consider the classic representation of an input-output system, in which the gross output in sector j of country r (y_i^r) is totally used as intermediate (z_{ij}^{rs}) or final consumption (c_i^r), either at home or abroad: $y_i^r = \sum_s c_i^{rs} + \sum_s \sum_j z_{ij}^{rs}$. Using technical coefficients derived from global input-output matrices, the intermediate usage from sector i of country r by sector j in s can be written as: $a_{ij}^{rs} = z_{ij}^{rs}/y_j^s$, then, substituting $a_{ij}^{rs} y_j^s$ to z_{ij}^{rs}, we obtain, in standard input-output vector/matrix form: $y = Ay + c$. Solving for y and rearranging, vector of gross outputs (y) is expressed as a function of the vector of final demand (c): $y = (I-A)^{-1}c$, where I is the identity matrix. $L = (I-A)^{-1}$ is the Leontief inverse matrix (or multiplier matrix), expressing the entire output required to produce one unit of consumption.

9 A different strand of research, out of the scope of our analysis, takes into account barriers other than bilateral, in order to impute the actual tariffs incurred by intermediates at different steps of processing in different exporting countries. In this vein, Rouzet and Miroudot (2013) define the ERP *for exporters* (ERPE), which depends on nominal tariffs in the destination country. Also, they propose the "cumulative tariffs" concept which, tracing cumulative tariffs backward to the origin of the product subject to tariffs, considers the full structure of tariffs incurred along the production chain.

under examination, in such a way that an unambiguous answer to a formerly defined economic question can be provided. The idea is to calculate a uniform tariff equivalent of a non-uniform tariff structure yielding the same value in terms of a specific variable (Anderson et al., 2013)[10]. Our *true* benchmark against which to measure trade policies will be defined after having introduced, in the next section, the original theoretical model adjusted for the factor content functions developed by Neary and Schweinberger (1986).

3. Model Specification

3.1 *The Original Model*

Anderson and Neary (1996; 2003) formulate the general model of a small tariff-distorted competitive trading economy[11], applying dual techniques to model trade policy. In general equilibrium, the income expenditure condition implies, given the utility (u), the domestic price vector (p), the vector of factor endowments (f):

$$e(p,u) - g(p,f) - \frac{\partial E}{\partial p}(p - p^*) - b = 0$$

where $e(p,u)$ are the expenditure functions, $g(p,f)$ the restricted profit functions, p^* are world prices, and b represents the lump-sum income from abroad needed to finance the gap between income and expenditure to achieve the exogenous level of utility.

The difference $e(p,u) - g(p,f)$ results in trade expenditure functions, $\mathrm{E}(p,u,f)$, giving the expenditure net of the income received from ownership of the factors of production The government collects and costlessly redistributes trade-related revenues, given by the import demand functions, $m(p,p^*,b,f) = \partial E/\partial p$and the tariff wedge, $(p - p^*)$. The general equilibrium level can be stated in terms of a function depending on the characterizing variables, in order to obtain the import volume functions at world prices for the k goods:

$$M(p,p^*,b,f) = p^* m(p,p^*,b,f)$$

10 Anderson and Neary (1994) were the first to propose this approach introducing the Trade Restrictiveness Index (TRI) to compute the *uniform price deflator which, applied to the new levels of distorted prices, yields the old level of utility of the representative agent*. Following this intuition, several alternative have emerged: Anderson (1998) re-define the (*distributional*) ERP in terms of the uniform tariff which is *equivalent to the actual differentiated tariff structure in its effect on rents to residual claimants in the sector*. The Mercantilist TRI developed by Anderson and Neary (2003) takes trade volume as the reference point. Antimiani (2004) computes the distortionary effects of protection on level of output.

11 Standard microeconomic assumptions are in place. For further details, refer to Dixit and Norman (1980), Neary and Sweinberger (1986), and Anderson and Neary, 2005.

Then, *the uniform tariff,* τ^{μ}, *that yield the same volume at world prices of tariff-restricted imports as the initial tariffs*, maintaining the equilibrium at b^0, can be defined for the reference period as:

$$\tau^{\mu}: M[(1+\tau^{\mu})p^*, b^0, f] = M^0(p^0, p^*, b^0, f)$$

where p^0 is the initially distorted price vector.

This iso-volume measure for the equivalent impact summarizes the extent to which trade distortions impact the import volumes, and it is thoroughly informative in the context of trade negotiations since it allows to distinguish the level and the effects of trade policy[12].

With the developments in the nature of international trade due to the rising of international fragmentation of production a gap between countries' national income and the value of final production has emerged, since imports contain domestic value added, and exports are produced importing foreign value added. Consequently, the bridge between macroeconomic models, reasoning in terms of value added, and trade statistics, recorded in gross values, seems to be falling down. This introduces new questions to be addressed. As previously mentioned, the protection imposed on imports limits imports from the rest of the world (and this is what Anderson and Neary's Mercantilist Trade Restrictiveness Index – MTRI - measures), and at the same time potentially impacts on domestic production. Moreover, when bilateral flows are under consideration, it could be useful an analytical framework that allows to distinguish that part of intermediate production embodied in bilateral imports which takes place in a third country. We recast the definition of the index to distinguish among these different effects. In order to do this, we first express the model in terms of factor content, shifting the focus from the actual trade in goods to the factor content of trade. Then we relax the assumption of domestic technology and we introduce a decomposition of bilateral imports accordingly to where the value added is generated.

3.2 *The Factor Content Approach and the Extended Model for Value-Added Analysis*

Following Neary and Schweinberger's (1986), trade in goods can be thought as indirectly trade in factor, then embodied factor trade could substitute for the commodity trade in terms of allowing the same level of utility. Under the assumption of constant returns to scale and in absence of joint production, techniques of production can be expressed by the amount of inputs used per unit of output. The technology of a one output-*f* inputs representative firm can be expressed by means of the unit cost function, $c(\omega)$, which is non-decreasing, concave, twice differentiable and homogenous of degree one with respect to factor prices, ω, implying that there are constant returns-to-scale. In competitive equilibrium, unit costs equals prices in equilibrium[13], then Marshallian import demand factor content functions are obtained (via a

12 Anderson and Neary (2005) suggest other applications of the index are, e. g., in measuring implicit trade costs, or in examining the link between openness and growth.

13 That is to say that the representative firm, in absence of any market power, prices at marginal cost. Under the constant returns to scale assumption, the marginal cost equals unit cost since the total cost

generalization of Roy's Identity and Shephard's Lemma) when the unit cost function is substituted for the *p* vector in the indirect utility function:

$$M_f(b,f) = \sum_j d_{fj}(\omega) m_j[c(\omega), b, f]$$ [14]

where d_{ij} are direct factor requirement coefficients of vector *D*, giving the factor *f* per unit of output in sector *j*. $M_f(b,f)$ expresses the total quantity of factor *f* embodied in imports when the production entirely utilizes the home country techniques. This specification is in line with the standard literature on factor content, where the assumption that intermediate goods are not traded is in place (see Johnson, 2011). Beside leading to an overestimation of the factor content (Reimer, 2006), this assumption is inconsistent with traded goods which combines portions of value added originated in different locations. With commodities produced in different stages performed in more countries, the *effective* techniques of production are a combination of domestic *and foreign* technologies. Deardorff (1982) gives the definition of *actual* factor content, which *imputes to traded goods those factors actually used in their production wherever that took place*. Trefler and Zhu (2010), in considering technology differences across countries, develop a widely used method in the computation of the factor content embodied in trade applying this definition. Defining T^r as the net trade vector for country *r* including imports as negative terms, we obtain their main equation which defines the net factor content of country *r*'s trade:

$$FC^r = D \times L \times T^r.$$

The technical coefficients matrix, A, over which L is calculated, is obtained from inter-country input-output tables[15] which differentiates goods across countries for the techniques actually used in its production (Reimer, 2011). By post-multiplying the *D* vector by the Leontief inverse, the *total* factor requirements for all stages of production of final goods is obtained. Since our interest is on the *value added* content of trade, following Johnson and Noguera (2012) and Stehrer et al. (2012), we consider value added shares in gross output instead of physical input coefficients.

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function is homogeneous of degree one with respect to the production level and both marginal and unit costs are invariant to the level of output.

14 For a formal proof, see Neary and Schweinberger (1986). The generalization of Roy's Identity states that *the derivatives of the indirect factor trade utility function with respect to factor prices are proportional to the factor content of net imports, the constant of proportionality being the marginal utility of income* (Neary and Schweinberger, 1986:424).

15 Trefler and Zhu (2010) use input-output tables from GTAP database and a proportionality assumption (that is, *an industry uses an import of a particular product in proportion to its total use of that product*) to compute the *world* A matrix. It is worth mentioning that the condition of no-traded input implies the off-diagonal blocks (which track the requirement for foreign intermediates) to have elements equal to zero. See Trefler and Zhu (2010) for a formal treatment of the relation between the two assumptions.

Define V as the diagonal matrix with diagonal elements equal to the share of direct domestic value added in total output in each sector of each country. The *total* value added multiplier, VL, provides a breakdown of the flows of value added across country/sector of production; diagonal (off-diagonal) sub-blocks represent domestic (foreign) value added in domestic production. Exploiting the property that the sum along each column of VL is unity, since all value added must be domestic or foreign, the bilateral flow, say from r to s, can be decomposed into three main components, namely, from the point of view of country s: a) the domestic value added originated in all sectors of s which is imported back from the sector i of country r (dva_imp)[16], b) the direct foreign value added originated in all sectors of the exporting country r embodied in its exports of sector i to s ($fvab\_imp$), and c) the indirect foreign value added of third countries which is indirectly imported by s from sector i of r ($fvai\_imp$). Formally:

$$m_i^{rs} = \underbrace{\sum_j v_j^s\, l_{j,i}^{sr} m_i^{rs}}_{dva\_imp} + \underbrace{\sum_j v_j^r\, l_{j,i}^{rr} m_i^{rs}}_{fvab\_imp} + \underbrace{\sum_j v_j^w\, l_{j,i}^{wr} m_i^{rs}}_{fvai\_imp}$$

At this point, we can calculate three uniform tariff equivalents yielding the same value of each component of the bilateral imports. Thus, the uniform tariff that, if imposed on imports instead of the existing structure of protection, would leave the *reflected* value added at its current level, is given by:

$$\check{\mathrm{T}}_{DVA,i}^{rs}: \sum_j v_j^s\, l_{j,i}^{sr} m_i^{rs}\left[\left(1 + \mathrm{T}_i^{(\mu)rs}\right) p^*(T), b^0, \omega\right] = \sum_j v_j^s\, l_{j,i}^{sr} m_i^{rs}\left(p^0, p^*(T), b^0, \omega\right)$$

16 Hummels et al. (2001)'s assumption that all imported intermediate inputs include only foreign value-added was first relaxed by Daudin et al. (2011) who introduced the concept of "reflected exports" ($VS1^*$), measuring *the exports that further down the production chain, are embedded in re-imported* [final] *goods*. Stehrer et al. (2012) give a measure of the domestic value added which is re-imported as final *and* intermediate imports. Amador and Stehrer (2014) label the same measure as "DVAiM" and give an application for the Portuguese trade in the period 1995-2011. Johnson and Noguera (2012) give an approximation of the amount of exports embedded as intermediates in goods that are reflected back to the source country, considering only first round effects of the Leontief inverse, $[\mathrm{I} + \mathrm{A}]$, that is, the direct effect on output linked to an increase in the final demand, and the effect on intermediate inputs directly needed to produce that output. Koopman et al. (2014) give a decomposition of intermediate flows according to the country of final absorption. This allow to isolate all portions of value which are double-counted in gross trade statistics due to intermediate inputs repeatedly computed when they cross border multiple times. Their $VS1^*$ measure captures the reflected trade embodied in final imports and the portion of value added which is re-imported for domestic processing and consumption. Wang et al. (2013) extend the Koopman et al. (2014)'s framework to the bilateral/sector level and further take into account the reflected value added which is imported back via a third country. We follow the method proposed by Stehrer et al. (2012) in using a trade vector which includes both final and intermediate imports, since our interest is on value added content of imports and not on final consumption, and, for the aim of our work, the computational difficulties implied by the decomposition of intermediate flows are not justified. Yet, it should be noted that the portion of re-imported intermediates which is used for producing final exports is over-counted, since it is already included in the product of VL and final trade. This may lead to an overestimation of our measure.

The same applies for the other two components of exports:

$$\check{T}^{rs}_{FVAB,i}: \sum_j v_j^r \, l_{j,i}^{rr} m_i^{rs}\left[\left(1 + T_i^{(\mu)rs}\right)p^*(T), b^0, \omega\right] = \sum_j v_j^r \, l_{j,i}^{rr} m_i^{rs}(p^0, p^*(T), b^0, \omega)$$

and:

$$\check{T}^{rs}_{FAVI,i}: \sum_j v_j^w \, l_{j,i}^{wr} m_i^{rs}\left[\left(1 + T_i^{(\mu)rs}\right)p^*(T), b^0, \omega\right] = \sum_j v_j^w \, l_{j,i}^{wr} m_i^{rs}(p^0, p^*(T), b^0, \omega)$$

4. Data and Application

4.1 The GTAP-MRIO Database

For the purpose of this study, we use a newly developed GTAP-MRIO database, derived from the reconciliation of trade data with the input-output structure available for each region[17], build on the GTAP Data Base version 9. The key aspect in the construction of a full MRIO table is that import sources are to be attributed for intermediate and final demand to individual source countries and sectors, while the standard GTAP database aggregates these flows at the border (Narayanan et al., 2012). Sourcing information from disaggregated trade data obtained from the UN COMTRADE database at the six digit HS level (obtain for the 2011 from the TASTE for GTAP 9) are mapped from the 5052 HS codes at the six digit level to 19 BEC end-use categories. Subsequently, a BEC-SNA concordance is used to explicitly map the 19 BEC categories to the SNA end use classes (intermediate use, final consumption, and capital goods). A final HS-GTAP concordance is applied to map each HS line to a GTAP commodity. This procedure ends up with values for intermediate and final demand denoted by source which have to be consistent with the rest of GTAP data, that is, they must add up to the total imports by source for each commodity in each use[18]. The rebalancing procedure follows the GTAP spirit, mainly focused on trade policy analysis, in giving the priority on trade data, which are kept intact allowing the split between domestic and imported goods contained in the input-output tables to adjust to reflect information from the BEC shares (for more details on this point, see Walmsley et al., 2014).

17 The database has been developed under the Public Procurement Project contracted by the Centre for Global Trade Analysis and the European Commission.

18 In GTAP notational conventions, purchases of imports i for use by j in region r, VIFMS(i,j,r,s), government demand for imports of i from s in region r, VIGMS(i,r,s), and private consumption expenditure on imported i from s in r, VIPMS(i,r,s), must add to the total value of imports of i from s to r, VIMS (i,r,s). Moreover, adding for all importing sources in each end use: $\sum_r VIFMS(i,j,r,s) = VIFM(i,j,s)$, $\sum_r VIGMS(i,r,s) = VIGM(i,s)$, and $\sum_r VIPMS(i,j,s) = VIPM(i,s)$.

4.2 The Extended GTAP Model

In our comparative static analysis, the economic assessment of trade restriction is performed through a multi-region, multi-sector global computable general equilibrium (CGE) model, based on the GTAP (Global Trade Analysis Project) model, designed to assess the inter-regional incidence of economic policies (Hertel, 2012). Under the assumptions of perfect competition and constant returns to scale, we maintain the consumption behavior of the standard GTAP model while the production structure is modified to reflect the data development previously described. The expenditures by the regional household are governed by a utility function which aggregates private consumption, government spending and savings. The utility function is nested as in the standard GTAP model, with a first aggregation made over distinct goods or sectors, and between the latter a choice is made over domestic or imported quantities. The import demand is modeled following the Armington aggregation structure, with an exogenously differentiation scheme given by the geographical origin of homogeneous products. The only difference here is that imports for the government and the private household reflect the origin of these imports. In the production tree assumed by the model (Figure 1), composite value-added (qva) and intermediates (qf) enter with fixed proportions (Leontief technology) in the production of output (qo), and intermediates are broken into the domestic and imported components. In order to incorporate the sourcing of imports in the production structure, the aggregate level for the sourcing decisions for imports has to be split at the agent level. This maintains the Armington assumption, which is now applied on demand for imports of the specific agent (government, private households, and firms) and not on the total demand for imports. For firms, this is done by adding a new nest level linking the imported intermediates (qfm) and the imports indexed by the country of origin (qifs).

Building on this structure, we introduce the decomposition of gross bilateral flows into the three components: reflected domestic value added, foreign value added of direct exporter, and redirected foreign value added (Figure 2).A coefficient for the value added share by source of production is introduced in order to compute for each component the value added originated in all sectors of, respectively, domestic, destination, and third countries which is embodied in total bilateral trade.

In order to compute the uniform tariff, we fallow Salvatici (2001), and Antimiani and Salvatici (2005) and define a new variable,$\mathrm{tr}(\mathrm{r},\mathrm{s})$, as the *product-generic tariff levied on imports from region r into region s*. To the model is then asked to remove taxes on imports from r into s, setting in the closure the component of value added we are interested in exogenous instead of previously exogenous $\mathrm{tr}(\mathrm{r},\mathrm{s})$.The tariff data in GTAP 9 Data Base are obtained from the ITC MAcMap data base[19].

19 For the documentation, see Guimbard et al. 2012.

5. Results and Conclusion

The comparative static analysis is performed through the modified GTAP model with 6 regions/countries - "European Union 28", "United States", “China”, “high income countries”, “middle income countries”, and “low income countries”[20] - and 6 sectors – agriculture, food, textiles, manufacturing, motor vehicles, and services (see Table1). The baseline refers to 2011.

Table 2 shows the results. Columns I to VI refer to the uniform tariff equivalents related to the value added components embodied in bilateral trade following the decomposition previously introduced. The indirect foreign value added is split among different countries/regions of origin (IV-VI). Column VII refers to the uniform tariff required in order to maintain the import volumes at their current levels, namely the MTRI measured in gross terms. In the last two columns are the ad valorem import tariff rates by sector (VIII) and the trade-weighted average tariff (IX). Values in row, except when referred to the ad valorem import tax, represent the contribution of each sector in the index.

Our results suggest that the weighted average scheme of aggregation is not reliable as an approximation of the protection on value added; in most cases it underestimates the protection, while it turns out to be overestimated for Chinese exports to United States. As expected, the distortionary effects of a tax on the import volumes in gross terms (column VII) are quite similar to the impacts on the exporter value added (column II).

The domestic value added face a significant protection level (column I) relative to the bilateral direct foreign value added, meaning that protection is heavily impacting upstream domestic firms exporting intermediate inputs processed abroad and then imported back. In the case of China, taxes on imports from United States and European Union impact Chinese re-imported value added more than the exporters value added.

Our results seem to reflect the major interconnectedness among European Union, United States and China, as can be seen from the fact that they are the most hit “third” countries in all the analyzed bilateral flows.

The value added originated in low-income countries in most of the cases results to be subjected to the lowest level of protection (column VI). Notwithstanding the heterogeneity characterizing this aggregate, this may suggest that low-income countries have a low degree of participation in GVCs or may reflect that preferential treatments are in place.

With regard to sectors, manufacturing drives most of the results. In Chinese bilateral exports, both manufacturing and textiles have the highest weights on each of the indexes. This is not explained by the protection structure since tariffs are consistently lower in these sectors,

20 Countries within the last three aggregates have been classified by their level of per capita gross national income following the United Nations classification, with threshold levels of GNI per capita established by the World Bank. “Middle income countries” include upper and lower middle income countries.

with the only exception of the United States protection on imports in textile. The economic size of these sectors obviously drives the results. However, looking at the imported value added content of exports at the sector level, we obtain the highest share for manufacturing, meaning that its relative downstream position in the value chain could give an explanation of its weight in the index.

Same policy implications can be sketched. First, we find that the European Union would take advantage from a trade agreement with the United Stated more than it would obtain liberalizing with China, as can be seen from the difference between the first two columns of table 2. Second, for the United States a less restrictive policy towards China would be beneficial for its domestic production, given the relatively high value of the index for domestic re-imported value added. Third, our results suggest an advantage for China in reducing tariffs on imports from the United States and European Union. Finally, the results related to the indirect foreign value added imply that there are benefits arising from the bilateral liberalization on "third" countries, supporting the view of regionalism as a favourable or potentially "constructive force in the world trade system" (Baldwin and Freund, 2011).

This paper has presented new indexes for the economic assessment of trade restriction in the contest of GVCs, which synthesizes the upstream/downstream linkages and the protectionist measures on different sectors. The value added trade restrictiveness indexes allow to assess the impact a bilateral protection has on different value added components/sources. Although our results are still preliminary, they give interesting indications on the beggar thyself' content of protectionism.

References:

Amador, J., & Stehrer, R. (2014). Portuguese Exports in the Global Value Chains. *Economic Bulletin*, Banco de Portugal, (April), 64-78

Anderson, J.E. (1998) Effective Protection Redux. *Journal of International Economics*, 44, 21-44.

Anderson, J.E., & Naya, S. (1969). Substitution and Two Concepts of Effective Rate of Protection. *American Economic Review*, 59, 607-612.

Anderson, J.E., & Neary, J.P. (1994). Measuring the Restrictiveness of Trade Policy. *World Bank Economic Review*, 8, 151-69.

Anderson, J.E., & Neary, J.P. (1996). A New Approach to Evaluating Trade Policy. *Review of Economic Studies*, 63(1), 107-125.

Anderson, J.E., & Neary, J.P. (2003). The Mercantilist Index of Trade Policy. *International Economic Review*, 44(2), 627-649.

Anderson, J.M.; Martin, W.J., & van der Mensbrugghe, D. (2013). Estimating Effects of Price Distorting Policies Using Alternative Distortions Databases. In P. Dixon and D. Jorgenson (eds.), *Handbook of Computable General Equilibrium Modeling*. Elsevier.

Anderson, K. (2003). Measuring Effects of Trade Policy Distortions: How Far Have We Come?. *The World Economy*, 26(4), 413–440.

Antimiani, A. (2004). A New Index to Evaluate the Effective Protection: An Application in a CGE Context. Paper presented at the 7th Annual Conference on Global Economic Analysis Trade, Poverty, and the Environment, Washington, D. C., United States.

Balassa, B. (1965). Tariff Protection in Industrial Countries: An Evaluation. Journal of Political Economy, 73(6), 573-594.

Baldwin, R. (2006). Globalisation: the great unbundling(s). *Economic Council of Finland*, 20(3), 5-47.

Baldwin, R. (2014). WTO 2.0: Governance of 21st century trade. *The Review of International Organizations*, 9(2), 261-283.

Baldwin, R., & Freund, C. (2011). Preferential Trade Agreements and Multilateral Liberalization. In Chauffour, J.-P., & Maur, J.-C. (eds.), *Preferential Trade Agreement Policies for Development: A Handbook*. WB, chapter 6.

Baldwin, R., & Robert-Nicoud, F. (2014). Trade-in-goods and trade-in-tasks: An integrating framework. *Journal of International Economics*, 92(1), 51-62.

Cappariello, R., & Felettigh, A. (2015). How does Foreign Demand Activate Domestic Value Added? A Comparison among the Largest Euro-Area Economies. *Temi di discussione*(Economic working papers), 1001. Bank of Italy, Economic Research and International Relations Area.

Chen, B., Jacks, D.S., & Ma, H. (2013). Revisiting the Effective Rate of Protection in the Late Stages of Chinese Industrialization. Working paper.

Cipollina, M., & Salvatici, L. (2008). Measuring protection: *mission impossible*?. *Journal of Economic Surveys*, 22(3), 577–616.

Corden, M.W. (1966). The Structure of a Tariff System and the Effective Protective Rate. *Journal of Political Economy*, 74(3), 221-237.

Daudin, G.; Rifflart, C.; Schweisguth, D. (2011). Who Produces for Whom in the World Economy?. *Canadian Journal of Economics*, 44(4), 1403-1434.

Deardorff, A.V. (1982). The General Validity of the Heckscher-Ohlin Theorem. *American Economic Review*, 72(4), 683–694.

Diakantoni, A., & Escaith, H. (2014). Trade in Tasks, Tariff Policy and Effective Protection Rates. MPRA Paper, 60675.

Diakantoni, A.; & Escaith, H. (2012). Reassessing Effective Protection Rates in a Trade in Tasks Perspective: Evolution of Trade Policy in Factory Asia. WTO Working Paper.

Dietzenbacher, E., Los, B. Stehrer, R., Timmer, M., & de Vries, G. (2013). The Construction of World Input-Output Tables in the WIOD Project. *Economic Systems Research*, 25(1), 71-98.

Dixit, A. K., & Norman, V. (1980). Theory of International Trade: a Dual, General Equilibrium Approach. London, Cambridge University Press.

Feenstra, R.C., & Hanson, G.H. (1996). Globalization, Outsourcing, and Wage Inequality. *American Economic Review Papers and Proceedings*, 86(2), 240–245.

Foster-McGregor, N., & Stehrer, R. (2013). Value Added Content of Trade: A Comprehensive Approach. *Economics Letters*, 120, 354-357.

Grossman, G.M., & Rossi-Hansberg, E. (2008). Trading Tasks: A Simple Theory of Offshoring. *American Economic Review*, 98(5), 1978-97.

Guimbard, H., Jean, S., Mimouni, M., & Pichot, X. (2012). MAcMap-HS6 2007, an exhaustive and consistent measure of applied protection in 2007. CEPII Working Paper, 10.

Hertel, T.W., & Tsigas, M. E. (1997). Structure of GTAP. In Hertel, T.W. (ed.), *Global Trade Analysis: Modeling and Applications*. Cambridge University Press, chapter 2.

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

IMF. (2013). Trade Interconnectedness: The World with Global Value Chains. IMF Policy Paper.

Johnson, R.C. (2011). Factor Trade Forensics: Intermediate Goods and the Factor Content of Trade. Unpublished Manuscript, Dartmouth College.

Johnson, R.C., & Noguera, G. (2012). Accounting for Intermediates: Production Sharing and Trade in value Added. *Journal of International Economics*, 86,224-236.

Koopman, R., Powers, W., Wang, Z., & Wei, S-J. (2010). Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains. NBER Working Paper, 16426.

Koopman, R., Wang, Z., & Wei, S.-J. (2012). Estimating domestic content in exports when processing trade is pervasive. *Journal of Development Economics*, 99(2), 178–189.

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

Krishna, K. (2009). Background Paper on the IMF's Trade Restrictiveness Index. MPRA Paper, 21316.

Leith, J.C. (1968). Substitution and Supply Elasticities in Calculating the Effective Protection Rate". *Quarterly Journal of Economics*, 82(4), 588-601.

Lejour, A., Rojas-Romagosa, H., &Veenendaal, P. (2014). Identifying Hubs and Spokes in Global Supply Chains Using Redirected Trade in Value Added. ECB Working Paper Series, 1670.

Leontief, W.W. (1936). Quantitative input and output relations in the economic system of the United States. *The Review of Economic Statistics*, 18(3), 105-125.

Los, B., Timmer, M., & Vries, G.J. de. (2015). How important are exports for job growth in China? A demand side analysis. *Journal of Comparative Economics*, 43(1), 19-32.

Los, B., Timmer, M.,& Vries, G.J. de. (2013). Globalization or Regionalization? A New Approach to Measure International Fragmentation of Value Chains. GGDC Research Memorandum, 138. University of Groningen.

Miroudot, S., & Yamano, N. (2013). Towards the Measurement of Trade in Value-Added Terms: Policy Rationale and Methodological Challenges. In Mattoo, A.M., Whang, Z., & Wei, S.-J. (eds.), *Trade in Value Added: Developing New Measures of Cross-border Trade*. The World Bank.

Narayanan, G., Aguiar, B.A.,& McDougall, R. (eds.). (2012). Global Trade, Assistance, and Production: The GTAP 8 Data Base. Center for Global Trade Analysis, Purdue University.

Neary, J.P., & Schweinberger, A.G. (1986). Factor Content Function and the Theory of International Trade. *The Review of Economic Studies*, 53(3), 421-432.

OECD, WTO, & WB. (2014). Global Value Chains: Challenges, Opportunities, and Implications for Policy. OECD, WTO and World Bank Group. Report prepared for submission to the G20 Trade Ministers Meeting Sydney, Australia, 19 July.

OECD. (2013). Trade Policy Implications of Global Value Chains: Contribution to the Report on Global Value Chains. Working Party of the Trade Committee, February.

OECD-WTO concept note. (2012). Trade in Value-Added: Concept, Methodologies and Challenges. http://www.oecd.org/sti/ind/49894138.pdf.

Reimer, J.J. (2006). Global Production Sharing and Trade in the Services of Factors. *Journal of International Economics*, 68(2), 384–408.

Reimer, J.J. (2011). "The Domestic Content of Imports and Foreign Content of Exports". *International Review of Economic and Finance*, 20:173:184.

Rouzet, D., & Miroudot, S. (2013). The Cumulative Impact of Trade Barriers along the Value Chain: An Empirical Assessment using the OECD Inter-Country Input-Output Model. Not published. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4184.

Stehrer, R., Foster, N., & de Vries, G. (2012). Value Added and Factors in Trade: A Comprehensive Approach. WIIW Working Paper, 80.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. &Vries, G. J. de. (2015). An Illustrated User Guide to the World Input–Output Database: The Case of Global Automotive Production. *Review of International Economics*, 23, 575–605.

Trefler, D., & Zhu, S. (2010). The Structure of Factor Content Predictions. *Journal of International Economics*, 82, 195-207.

UNCTAD. (2013). Global Value Chains and Development. Investment and Value Added Trade in the Global Economy. A Preliminary Analysis. United Nations.

UNCTAD. (2015). Global Value Chains and South-South Trade. Economic Cooperation and Integration among Developing Countries. United Nations.

Vanek, J. (1968). The Factor Proportions Theory: The N-Factor Case. *Kyklos* 21, 749–756.

Walmsley, T., Hertel, T.& Hummels, D. (2014). Developing a GTAP- based multiregion, input–output framework for supply chain analysis. In Ferrarini, B., & Hummels, D. (eds.), *Asia and Global Production Networks-Implications for Trade, Incomes and Economic Vulnerability*. ADB, chapter 2.

Wang, Z., Wei, S-J., & Zhu, K. (2013). Quantifying International Production Sharing at the Bilateral and Sector Levels. NBER Working Paper, 19677.

Yamano, N., & Ahmad, N. (2006). The OECD Input-Output Database: 2006 Edition. OECD Science, Technology and Industry Working Papers, 8.

Yi, K.-M. (2003). Can Vertical Specialization Explain the Growth of World Trade? *Journal of Political Economy*, 111(1), 52-102.

Yi, K.-M. (2010). Can multi-stage production explain the home bias in trade? *American Economic Review*, 100(1), 364–393.

Table 1 *GTAP database aggregation*

Commodities and Activities*
Primary
Food
Textiles
Manufacture
Motor vehicles
Services
Country/Region*
European Union 28
United States of America
China
High income countries
Middle income countries
Low income countries
Endowment commodities (mobile)**
Labor
Capital

* Primary: paddy rice; wheat, cereal grains nec; vegetables, fruit, nuts; oil seeds; sugar cane, sugar beet; plant-based fibers; crops nec; bovine cattle, sheep and goats, horses; animal products nec; raw milk; wool, silk-worm cocoons; forestry; fishing. Food: bovine cattle, sheep and goat meat products; meat products; vegetable oils and fats; dairy products; processed rice; sugar; food products nec; beverages and tobacco products. Textiles: textiles; wearing apparel; leather products. Manufacture: coal; oil; gas; minerals nec; wood products; paper products, publishing; petroleum, coal products; chemical, rubber, plastic products; mineral products nec; ferrous metals; metals nec; metal products; electronic equipment; machinery and equipment nec; manufactures nec. Motor vehicles: motor vehicles and parts; transport equipment nec. Services: electricity; gas manufacture, distribution; water; construction; trade; transport nec; water transport; air transport; communication; financial services nec; insurance; business services nec; recreational and other services; Public Administration and defense, education, health; ownership of dwellings)
** European Union 28: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. High income countries: Australia, Bahrain, Brunei Darussalam, Canada, Hong Kong, Israel, Japan, Korea Republic of, Kuwait, New Zealand, Norway, Oman, Puerto Rico, Qatar, Saudi Arabia, Singapore, Switzerland, Taiwan, Trinidad and Tobago, United Arab Emirates. Middle income countries: Albania, Argentina, Armenia, Azerbaijan, Belarus, Botswana, Brazil, Cameroon, Caribbean, Chile, Colombia, Costa Rica, Cote d'Ivoire Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Iran Islamic Republic of, Jamaica, Jordan, Kazakhstan, Lao People's Democratic Republic, Malaysia, Mauritius, Mexico, Mongolia, Morocco, Namibia, Nicaragua, Nigeria, Pakistan, Paraguay, Peru, Philippines, Rest of Central America, Rest of East Asia, Rest of Eastern Europe, Rest of Europe, Rest of Former Soviet Union, Rest of North Africa, Rest of North America ,Rest of South America, Rest of Southeast Asia, Rest of Western Asia, Russian Federation, Senegal, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Viet Nam, Zambia, Bolivia, Panama, Ukraine. Low income countries: Bangladesh, Benin, Burkina Faso, Cambodia, Central Africa, Ethiopia, Guinea, Kenya, Kyrgyzstan, Madagascar, Malawi, Mozambique, Nepal, Rest of Eastern Africa, Rest of Oceania, Rest of ROW, Rest of South African Customs Union, Rest of South Asia, Rest of the World, Rest of Western Africa, Rwanda, South Central Africa, Tanzania United Republic of, Togo, Uganda, Zimbabwe.
*** Capital: land, capital, natural resources.

Table 2 *Value Added Trade Restrictiveness Indexes*

European Union 28 imports from United States

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
	$\check{T}_{DVA\_eu}$	$\check{T}_{FVAB\_usa}$	$\check{T}_{FVAI\_chn}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**2,03**	**2,08**	**1,99**	**1,87**	**1,88**	**1,69**	2,04		1,30
primary	0,02	0,05	0,01	0,01	0,01	0	0,05	3,26	
food	0,15	0,28	0,07	0,1	0,13	0,04	0,25	13,1	
textiles	0,09	0,09	0,17	0,05	0,07	0,04	0,09	6,74	
manufacture	1,21	1,28	1,22	1,32	1,34	1,46	1,29	1,55	
motor vehi	0,56	0,37	0,52	0,39	0,33	0,15	0,37	2,87	

European Union 28 imports from China

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	$\check{T}_{DVA\_eu}$	$\check{T}_{FVAB\_chn}$	$\check{T}_{FVAI\_usa}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**3,07**	**3,82**	**3,71**	**2,99**	**2,93**	**2,37**	3,83		3,57
primary	0	0,03	0,01	0	0	0	0,02	3,81	
food	0,04	0,16	0,16	0,03	0,09	0,02	0,14	11,3	
textiles	1,22	2,05	1,93	1,17	1,05	0,43	2,08	10,4	
manufacture	1,63	1,49	1,52	1,69	1,73	1,87	1,5	1,99	
motor vehi	0,17	0,09	0,1	0,1	0,06	0,05	0,09	2,74	

United States imports from European Union 28

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	$\check{T}_{DVA\_\mathrm{usa}}$	$\check{T}_{FVAB\_eu}$	$\check{T}_{FVAI\_chn}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**1,22**	**1,37**	**1,42**	**1,21**	**1,27**	**1,28**	1,36		0,91
primary	0	0,01	0	0	0	0	0,01	2,14	
food	0,05	0,1	0,03	0,03	0,05	0,07	0,09	2,46	
textiles	0,16	0,28	0,39	0,14	0,18	0,17	0,27	7,67	
manufacture	0,84	0,87	0,86	0,91	0,95	0,96	0,87	1,12	
motor vehi	0,16	0,12	0,13	0,12	0,09	0,08	0,11	0,77	

(*Continued*)

Table 2 *Value Added Trade Restrictiveness Indexes* (*Continued*)

United States imports from China

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
	$\check{T}_{DVA\_usa}$	$\check{T}_{FVAB\_chn}$	$\check{T}_{FVAI\_eu}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**2,4**	**2,49**	**1,92**	**1,87**	**1,79**	**1,38**	2,73		2,83
primary	0	0	0	0	0	0	0	0,99	
food	0,04	0,04	0,01	0,01	0,02	0	0,03	2,8	
textiles	1,36	1,46	0,83	0,79	0,7	0,26	1,73	11,5	
manufacture	0,96	0,95	1	1,03	1,04	1,1	0,92	1,14	
motor vehi	0,05	0,04	0,08	0,05	0,03	0,02	0,04	1,6	

China imports from European Union 28

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	$\check{T}_{DVA\_chn}$	$\check{T}_{FVAB\_eu}$	$\check{T}_{FVAI\_usa}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**7,85**	**7,64**	**8,22**	**7,51**	**7**	**6,82**	7,57		7,07
primary	0,03	0,1	0,04	0,03	0,04	0,05	0,09	10,2	
food	0,09	0,25	0,13	0,09	0,14	0,18	0,23	11,6	
textiles	0,38	0,28	0,17	0,15	0,19	0,18	0,27	9,85	
manufacture	3,9	3,99	3,78	4,13	4,36	4,43	4,03	5,28	
motor vehi	3,44	3,03	4,11	3,11	2,17	1,97	2,95	16,3	

China imports from United States

	Uniform tariff equivalents							*Ad valorem import tariffs*	*Trade-weighted average tariff*
	$\check{T}_{DVA\_chn}$	$\check{T}_{FVAB\_usa}$	$\check{T}_{FVAI\_eu}$	$\check{T}_{FVAI\_hics}$	$\check{T}_{FVAI\_mics}$	$\check{T}_{FVAI\_lics}$	$\check{T}_{GI}$		
total	**5,62**	**5,2**	**5,69**	**5,26**	**5,15**	**4,66**	5,16		4,78
primary	0,13	0,35	0,18	0,12	0,11	0,07	0,34	3,23	
food	0,11	0,32	0,2	0,15	0,19	0,09	0,29	9,93	
textiles	0,23	0,12	0,12	0,08	0,1	0,06	0,12	7,25	
manufacture	3,06	2,98	2,97	3,3	3,36	3,69	3,02	4,1	
motor vehi	2,09	1,44	2,21	1,62	1,39	0,75	1,4	12,3	

Figure 1 *Production structure in the GTAP model*

(Version 6.2-SC, which introduces sourcing of imports by agent):

```
                    --------------------
                         qo(j,r)
                           /\
                          /  \   <----- CES
                         /    \
                        /      \
                       /        \
                qva(j,r)        qf(i,j,r)
                  /|\                /\
CES ----->       / | \              /  \   <------ CES
                /  |  \            /    \
               /   |   \          /      \
              /    |    \        /        \
          Land   Labor  Capital  Domestic    Foreign
             qfe(i,j,r)          qfd(i,j,r)   qfm(i,j,r)
                                               |
                                               |
                                               |  <------ CES
                                               |
                                              qifs(i,j,s,r)
```

Source: Based on figure 2.6 in Hertel and Tsigas (1997)

Figure 2 *Bilateral imports decomposition*

```
            ------------

                 qxs
               (i,r,s)
                 /|\
                / | \
               /  |  \
              /   |   \
             /    |    \
     dva_imp  fvab_imp  fvai_imp
     (i,r,s)  (i,r,s)   (i,r,s)
```
