doi: 10.1111/j.1467-6419.2007.00543.x

MEASURING PROTECTION: MISSION IMPOSSIBLE?

Maria Cipollina and Luca Salvatici

University of Molise

Abstract. There seems to be some confusion between 'openness' and 'protection' measures in the international trade literature. The aim of this paper is to bring together the state of the art in quantifying trade policy measures and, for this reason, we focus on the extent of the protection granted by policies rather than on the degree of openness of the economy. Given the considerable amount of literature that deals with these issues, we will limit our review as follows. On the one hand, we focus on trade policies implemented at the border and therefore do not consider all the other possible public interventions influencing trade flows. On the other hand, we only take into account indexes that explicitly adopt a metric expressed in a 'scalar aggregate' (tariff- and quota-equivalent measures, or an index in a closed interval). We distinguish between indexes that aggregate across products (same barrier for more products) and indexes that aggregate across instruments (more barriers for the same product). Finally, in order to classify the large number of indexes covered in our review, we propose a typology based on three categories: incidence, outcome and equivalence.

Keywords. Protection; Tariff and non-tariff barriers; Tariff and non-tariff measures

1. Introduction

This paper provides a survey of attempts to capture empirically the seemingly intuitive notion of trade restriction. Protectionism is simultaneously one of the most used and vaguely defined terms in contemporary policy discussion. Our point of departure relative to the literature is the measurement of trade restriction and we will assess how protected particular economies are and how rapidly or indeed slowly liberalization is occurring.

As is well known, empirical research to date has offered several and perhaps too many protection indexes. On the one hand, this is because it is hard to obtain detailed and accurate information on trade policy, and internationally comparable data, especially on non-tariff barriers (NTBs), are difficult to obtain. On the other hand, there has been considerable confusion between 'openness' and 'protection' measures. This is especially true for the literature that focuses on the linkage between trade policy and growth (Heitger, 1987; Dollar, 1992; Sachs and Warner, 1995; Harrison 1996; Edwards, 1993, 1998; Frankel and Romer, 1999; Rodriguez and Rodrik, 1999; Baldwin, 2003; Yanikkaya, 2003). Trade openness not only depends on the levels of restrictions but also on a set of non-policy variables such as endowments, size, tastes and technology. Since the concept of openness is linked to trade intensity, one might think that a low degree of openness implies a high degree of protection. However, this would be quite wrong: the lack of openness is neither a necessary nor a sufficient condition for protection. Relatively modest trade flows may be due to several factors that are not related to trade policy and two different countries may register the same level of openness irrespective of the implementation of different trade policies or a different level of openness even if they implement the same trade barriers. Even if there are obvious links, openness and protection are seemingly two different concepts.

We define *trade protection* as a set of government policies imposed in order to protect domestic producers against foreign competition from cheaper imported goods and services. The paper focuses on the measurement of the protection granted by policies rather than on the assessment of the structural degree of openness of the economy. Furthermore, we focus on policy indexes rather than on the evaluation of the policy impact. This implies that we only consider scalar indexes based on metrics expressed in terms of prices (e.g. tariff-equivalent measures) or in terms of quantities (e.g. quota-equivalent measures) or using an *ad hoc* scalar included in a closed interval.

The consequences of a given policy may provide the weights for the aggregation scheme but they are not of interest *per se*. This allows us to exclude from the review the literature, starting with Balassa (1985) and Leamer (1988), which focuses on the deviations of the actual volume of exports from the volume predicted by a simple structural model of trade. More recently, a vast and growing literature based on gravity models assesses the difference between potential and actual trade flows. These papers are not considered here, even if they use trade policy variables to explain trade patterns or deviations from the predicted pattern.

Protection indicators should fulfil certain requirements and constraints: ideally, they ought to be comprehensible, transparent and capable of straightforward interpretation. Operationally, any measures of protection should meet the following requirements:

1. they should be able to indicate if a protectionist policy exists,
2. they should be able to rank different policies according to their degree of restrictiveness and
3. they should guarantee a consistent scaling of all degrees of restrictiveness.

Measures of protection have long been of interest to international economists and this interest has been renewed with the introduction of a new approach to gauging trade restrictiveness which draws on the theory of index numbers (Anderson, 1995). A huge amount of research has been undertaken on this subject including numerous excellent surveys such as Baldwin (1989), Laird and Yeats (1990), Linkins and Arce (1994), Pritchett (1996), Deardorff and Stern (1998), Anderson (2002) and Ferrantino (2006). However, most of them only focus on NTBs or fail to account properly for the most recent developments in this field of the literature.

We do not pretend to be comprehensive; rather, our aim is to offer a 'road map' through this large quantity of literature: those seeking a detailed discussion of specific issues should refer to the papers themselves. When organizing the survey, we had two contrasting objectives. On the one hand, we wanted the studies to be consistent with one another in order to ensure comparability. On the other hand, we wanted to encompass a variety of methodological approaches such as general or partial equilibrium models, or econometric estimates. The common feature of the papers considered is the attempt to construct measures that summarize the levels of trade restrictions implied by different policy instruments on different traded commodities.

The next section defines the boundaries of our review and provides a typology to classify existing indexes. In order to keep the paper within reasonable bounds, we focus on import related policy instruments implemented at the border such as measures to control the volume (e.g. quota restrictions and licences) or the price of imports (e.g. tariffs) and we limit our analysis to the literature that summarizes these trade policy instruments using a common metric. Accordingly, (1) we do not consider other public policies such as monetary or domestic policies, although they may have a very significant protectionist impact, and (2) we do not consider the studies focusing on the consequences of trade policies, as is the case for gravity models.

There are two fundamental obstacles to constructing summary statistics of the overall level of trade restrictions in an economy. On the one hand, in order to summarize different policy instruments they must be expressed in a common metric. This is the *conversion* problem and the solutions proposed in the literature are reviewed in Section 3. On the other hand, the level of trade restriction in each industry must be appropriately weighted. This is the *index number* problem. Section 4 reviews the weights used in the literature. Finally, theoretical and practical virtues and failings of the different methods of measurement are discussed in Section 5, and Section 6 concludes.

2. Structure of the Review

Two main hurdles, conversion and aggregation problems, need to be overcome to answer what, at first hand, appears to be a simple question: 'how should we measure the protection of a country's trade policy'? On the one hand, protection can take many different forms – tariffs, quotas, antidumping duties, technical regulations – and so we need to convert the different instruments into a common metric. Since any trade policy has impacts on different areas (producer or consumer welfare, volume of trade, efficiency loss, etc.), there is no perfect solution for converting them into an *ad valorem* equivalent. For example, the equivalence between tariffs and import quotas has attracted a large body of research which shows that 'full equivalence' (in terms of all relevant economic effects) is almost never valid because it requires very stringent assumptions (Bhagwati, 1965).

A typical way to overcome this problem is to transform trade policies into *ad valorem* equivalents (AVEs). In principle, this solves the first aggregation problem since we summarize the trade restrictiveness of different trade policy instruments applied on imports of a particular good. If we were to focus on a single good, the assessment of protection would be done but, unfortunately, trade policy is set at the tariff line level and there are literally thousands of tariff lines in a typical tariff schedule. Then, all this information needs to be summarized in one aggregate and economically meaningful measure. At minimum for economic modelling, the aggregation must convert individual tariff lines into aggregates that conform to higher-level aggregation for production/consumption data.

Here a 'policy' is considered a conscious act of legislation as opposed to a circumstance or economic condition. Even limiting ourselves to the measures concerning the exchange of international goods, not services, there are a wide array of policy instruments that affect international trade. If we adopt a policy coverage based on the economic effects, the list of measures that have price-raising, trade-reducing, welfare-reducing, or other economic effects is likely to be endless. Consequently, we do not consider indexes concerning policies which may have an indirect effect on imports or exports but which are not directly applied at the border. More specifically, we do not consider indicators based on monetary policies (Aitken, 1973; Bhagwati, 1978; Krueger, 1978; Dollar, 1992; Chen, 1999) and on domestic policies such as social and industrial policies (World Bank, 1987; OECD, 1994; Sachs and Warner, 1995; Edwards, 1998).

The focus of this review is on trade policies implemented at the border, which includes measures to control the volume of imports, the price of imported goods, technical barriers, tariff and para-tariff measures. We classify the indexes proposed in the literature in three categories.

1. *Incidence* measures are based on the intensities of the policies themselves so that they are derived from direct observation of the policy instruments. They measure the level of protection without considering the rate at which it is translated into market (economy) specific trade *distortions*. They provide a sort of 'self-contained' assessment of the policies under consideration since they ignore any effects of these policies on specific markets (economies). The level or dispersion of tariffs (see Section 4.1) or the frequency of the various types of NTBs (see Section 3.1) are typical examples of incidence measures. These indexes appear to be far from satisfactory but it should be recalled that international trade policy commitments are usually expressed as incidence measures. More sophisticated indexes, as a matter of fact, introduce 'variables' (typically the weights to be used in the aggregation) that are different from the policies under consideration and policy-makers do not want compliance to be influenced by events that are out of their control.
2. *Outcome* measures are based both on policy variables and 'weights' – such as trade, production or consumption shares, GDPs, etc. – to be used in the aggregation process.[1] This means that some economic effects of existing policies are taken into account though these indexes remain 'a-theoretic' since they are not computed according to 'equivalence criteria' (e.g. welfare, volume of imports). On the other hand, at least some of these measures such

as the trade-weighted average tariff (see Section 4.2) can be interpreted as first-order approximations to some 'true' equivalence indexes. Moreover, it is worth noting that there are cases of outcome measures using 'counterfactual' weights, i.e. weights based on estimated rather than observed data. Examples of this type of index are the so-called 'generalized moments' (see Section 4.2).

3. *Equivalence* measures provide results that are equivalent to the original data in terms of the information we are interested in. The greatest advantage of this class of measures is that they are unequivocal because their definition is predetermined. These indexes provide an assessment of how far actual observations are from other hypothetical equilibria. As a result, explicit model structures and/or estimated parameters are needed for computation. Since they are not only based on observed data (as for outcome measures), they require some maintained assumptions in terms of model or methodology.

Models allow computation of an index of restrictiveness, which is 'equivalent' to the actual policies in terms of the chosen impact. Econometric approaches are used for *ex post* analysis whereas partial or general equilibrium models allow for the creation of counterfactual scenarios (Piermartin and The, 2005). As a result, equivalence measures are not only dependent on the structural features of the economy but they are 'model dependent' in that the value of the index will vary as the underlying modelling choices and parameters change. On the other hand, theoretically sound indexes provide benchmarks that can also be useful for the interpretation of the most widely used outcome measures.

Equivalence measures have been mostly developed by Anderson and Neary through several indexes (e.g. TRI, MTRI, DERP: see Section 4.3). The large number of applications carried out in recent years can be classified according to several dimensions: type of equivalence (e.g. welfare, profits, etc.), type of model (econometric, partial or general equilibrium), type of metrics (price or quantity) and type of assessment (absolute or relative measures).

In conclusion, the main differences between the three typologies refer to two main aspects: existence of an *equivalence* criterion and use of a *counterfactual* approach. The definition of an equivalence criterion implies that the construction of an index will depend on the purpose of the index itself. The use of a counterfactual approach implies that the calculation of the index does not only rely on observed data but requires the use of statistical or equilibrium models in order to assess what would have happened after a policy change. Table 1 summarizes the main indexes considered in this survey, divided into the different categories.

For aggregation across products, both equivalence and outcome measures represent weighted averages of individual commodity protection rates. However, with regard to equivalence measures, the weights represent the effects of the tariffs according to a fundamental economic structure. This is not true for the weights used in the outcome measures although some of these measures might be interpreted as fixed-weight approximations to theoretically based (i.e. equivalence) indexes.

Table 1. Synoptic Table.

Counterfactual approach	Equivalence criterion	
	Yes	**No**
Yes	Equivalence: • Trade restrictiveness indexes • Price/quantity equivalents	Outcome (estimated weights): • Generalized moments
No	Outcome (first-order approximations): • Weighted tariff moments • Effective rate of protection • Price wedges	Incidence: • Tariff moments • Tariff escalation • Frequency ratios

For example, the relationship between the trade-weighted average and the true average tariff is identical to that between the Laspeyres price index and the Konüs true cost-of-living index in consumer theory (see Section 4.3). This is why, in Table 1, we consider the trade-weighted average as an example of indexes based on an equivalence criterion without using any counterfactual data in the computation. On the other hand, we can also think of outcome measures requiring counterfactual data for their computation but without any interpretation in terms of equivalence criteria: this is the case for the 'generalized moments' (see Section 4.2).

3. Aggregation Across Policy Instruments

NTBs are well known to be pervasive, difficult to quantify and politically sensitive (Dee and Ferrantino, 2005). They are pervasive because regulations designed to address legitimate market failures may have incidental but unwarranted effects on trade. They are difficult to quantify since they are not published in tariff schedules and are not expressed in simple 'metrics' such as percentage or monetary values. Finally, they are politically sensitive because measures that are difficult to quantify may also be less transparent which helps to avoid public discussion. When such measures do receive public attention, their direct impact on trade may be less clear to the public than easily quantified measures such as tariffs.

Quantitative measures of NTBs have long been of interest to international trade. Bora *et al.* (2002) give guiding principles for measuring NTBs: 'first of all, non-tariff measures should be constructed to reflect equivalence to tariffs in terms of their effects on the domestic prices of the traded goods. Only direct effects on domestic prices should be used to define tariff equivalence .... There are many NTBs in practice for which high-quality measures are simply not available. Given the uncertainty that surrounds the measurement of NTBs, it would be best to construct approximate confidence intervals. Estimates of NTBs should be done at the most disaggregated levels possible' (p. 14). Laird and Yeats (1990), Deardorff and Stern (1998) and more recently Ferrantino (2006) offer an accurate description of various NTBs and discuss the progress made in the quantification of their effects.

3.1 *Incidence Measures*

Data on restrictions such as the number of restrictions can be used to construct various statistical indicators. The most common incidence measures are frequency-type measures based upon inventory listings of observed NTBs that apply to particular countries, sectors, or categories of trade.

Measures used to evaluate the level of non-tariff restrictions are the average coverage of quantitative restrictions given by the percentage of goods affected by quotas or voluntary export restraints (Edwards, 1998). More generally, the frequency-type measures record the number, form and trade coverage of non-tariff policies as determined by special surveys, frequency of complaints by trading partners and government reports (Baldwin, 1989). They are simple statistics used to provide an indication of the frequency of occurrence of NTBs.[2]

The NTB frequency (F) expresses the fraction of imports subject to NTBs, considering each category of world trade in that category (Nogues *et al.*, 1986; OECD, 1994; Bacchetta and Bora, 2001). The frequency index is given by the percentage of import transactions covered by a selected group of NTBs for an exporting country j:

$$F_j = \frac{\sum_k D_{kt} V_k^*}{\sum_k V_k^*} \cdot 100 \tag{1}$$

where D_k is a dummy variable that takes the value of one if NTBs are applied to the tariff line item k and zero otherwise; $V_k{}^*$ is a dummy variable that indicates whether there are imports from the exporting country j of good k.

NTB coverage ratios appear not to effectively capture how severe NTBs are (Dollar and Kraay, 2004). The main shortcoming of these measures is that they do not take into account the different importance of the barrier across sectors and products since they do not assess how restrictive each barrier is. One sector can have a number of products that are subject to low NTBs whereas other sectors can have very restrictive NTBs for few products. However, the first sector will have a much higher NTBs coverage ratio than the second one. For this reason, any interpretation using these measures should be made with extreme caution. Nevertheless, these indexes are useful for providing an indication of existing barriers, especially when reliable and detailed information necessary for construction of tariff equivalent are not available.

A final example of incidence measure is the R-index of restrictiveness of product-specific rules of origin constructed by Estevadeordal (2000) and Cadot *et al.* (2005). It is an ordinal index computed at the tariff line level ranging from one (least restrictive) to seven (most restrictive). In addition to the inevitable arbitrariness, the

R-index has other shortcomings. It does not control the degree of preferences and the characteristics of the different activities: satisfying a change of tariff classification that involves a change at the heading level for intermediate activities is likely to be easier than satisfying a final good activity.

3.2 *Outcome Measures*

Outcome measures are based on both policy and observed data to be used as 'weights' in the aggregation process. Frequency of occurrence of NTBs (represented by the share of total tariff lines containing NTBs) can also be expressed in weighted terms based on either imports or production. Usually, the weights used are percentage of imports. For example, import coverage ratios of NTBs can be weighted by the value of imports of each commodity subject to NTBs as a percentage of imports in the corresponding product category. The percentage of trade subject to NTBs for an exporting country j at a determined level of product aggregation can be expressed by the trade coverage ratio (C):

$$C_j = \frac{\sum_k D_k M_k}{\sum_k M_k} \cdot 100 \tag{2}$$

where D_k is a dummy variable that takes the value of one if NTBs are applied to the tariff line item k and zero otherwise; M_k is the value of imports in item k.

A typical problem of any trade-weighted measures is due to the endogeneity of the weights. The existence of NTBs, reducing imports from country j, has a negative impact on weight M so that the trade coverage ratio will be downward biased. In order to minimize this problem, the weights could be provided by the shares in domestic production. In any case, these production-weighted indexes may not be consistent since the actual effect of the NTBs varies according to products and countries and this kind of index cannot show which are binding (and how much these affect the economy) and which are not (Andriamananjara and Nash, 1997).

Recognizing that detailed tariff equivalents of NTBs are not readily available at the tariff line level, Cline (2005) recommends that NTB coverage ratios (the share of production or trade affected by NTBs) be converted to AVEs through the use of benchmark NTB weights. The benchmark NTB weights are subjective assessments of the distortionary effects of NTBs relative to an equivalent average tariff rate.[3] Fontagné *et al.* (2001), on the other hand, calculate different NTB coverage ratios (as the fraction of affected imports on world imports) establishing different thresholds in terms of potentially affected world imports.[4]

The IMF (2005) elaborates a non-tariff restrictiveness rating (NRR) that consists of a three-point scale that evaluates a country's use of non-tariff trade restrictions (such as quotas, restrictive licensing requirements, bans, state trading or exchange restrictions) based on the aggregate amount of trade or production affected: value 1 means that NTBs are absent or minor (less than 1% of production or trade are subject to NTBs); value 2 means that NTBs are significant, applied to at least one important sector (between one and 25% of production or trade are affected by NTBs); and finally, value 3 means that many sectors, or entire stages of production, are covered by NTBs (more than 25% of production or trade is affected).

The most obvious limitation of the IMF-NRR is the insufficient differentiation of intensity between the ratings. The use of only three broad categories allows for a ‘lumping effect’ due to the fact that countries with significantly different non-tariff policies are grouped together. For example, both a country with only minor barriers covering 5% of trade and a country with up to 25% of trade affected will have the same rating.

NTBs tend to limit trade so that they create scarcity and high prices. Then, the degree of NTB restrictiveness can be measured by the price differential that it drives between the price of imported goods and the producer price of the domestic substitutes, or alternatively, between the domestic and the world price. The wedge between the distorted and the non-distorted prices is the key input used in studying the potential economic effects of the removal of existing NTBs.

The price wedge is equal to the difference between the domestic price of a good which is protected by NTBs and the reference price of a comparable good in order to provide an AVE (Beghin and Bureau, 2001).[5] Price comparison techniques provide direct measures of price impacts of NTBs, the so-called implicit tariffs or implicit rates of protection. Ideally, the prices that would prevail both with and without the NTB must be known. However, most of the literature relies on price-gap approaches expressing the degree to which NTBs raise domestic prices above international prices.

In order to put various policy instruments together so that they can be compared, summed or used in large-scale modelling exercises, the natural solution is to compute AVEs of each instrument. The overall level of protection imposed by country i on imports of good k can be written as

$$pr_{i,k} = ave_{i,k} + \tau_{i,k} \tag{3}$$

where $pr_{i,k}$ is the overall level of protection that country i imposes on imports of good k; $ave_{i,k}$ is the AVE of NTBs that country i imposes on imports of good k and $\tau_{i,k}$ is the *ad valorem* tariff applied by country i on imports of good k.[6]

The wide multiplicity of trade barriers (NTBs such as quotas, import licence requirements, domestic content requirement, tariff and para-tariff charges and so forth) makes it difficult to construct an *ad valorem* index of trade restrictiveness that is comparable across countries and over time. Even limiting ourselves to tariffs, there is no perfect solution for converting a specific tariff into an AVE since a specific tariff provides higher protection to low unit value goods, i.e. to unprocessed or low quality goods (Feenstra and Boorstein, 1991). The approximation will always be local for a given value of a world price.

The tariff equivalent (*TE*) represents the rate, t, by which the domestic border price, P_k, of the imported good exceeds the price, P_i, paid by domestic importers to foreign exporters, inclusive of transport costs to the importing country and any tariffs levied by this country:

$$TE = \frac{P_k - P_i}{P_i} \tag{4}$$

This measure captures the effects of NTBs as well as tariffs. Nevertheless, it requires data that are not readily available in many countries.

Many attempts to assess the effects of NTBs use retail price data since they are easier to observe than prices at other stages of the supply chain (Deardorff and Stern, 1997, Bradford, 2003; Dean *et al.*, 2003; Andriamananjara *et al.* 2004). The most widespread critique on the use of retail price is that many primary and intermediate traded goods do not have retail prices and the presence or absence of NTBs may affect them differently. Furthermore, they contain wholesale and retail margins that complicate the identification of the NTB mark-up (Ferrantino, 2006). More generally, the main limitation is that formulae measuring NTBs in an implicit way (as a percentage price wedge between imports and domestic prices) are valid only under the assumption that imported goods are perfect substitutes (Baldwin, 2003). Without perfect substitutability, price wedges are not only due to NTBs: since available data are often too aggregated to reflect differences in the quality of imported goods, the interpretation of the results is questionable.

Price gap measures of final goods trade protection in OECD economies are presented by Bradford (2003). He focuses on NTBs to goods trade, uses retail price data, along with direct data on distribution margins, transport costs and indirect taxes from input–output sources, and uses a level of product classification where perfect substitution is more likely to be a reasonable assumption in order to generate estimates of overall price gaps between goods in different countries. He then converts consumer prices to producer prices using data on distributional margins (wholesale trade, retail trade and transportation costs). His measure of protection is

$$pr_{ik} = \max(ppr_{ik}, 1 + tar_{ik}) \tag{5}$$

where tar_{ik} is the tariff rate for good k in country i and ppr_{ik} is given from the ratio of each country's producer price to the world price, P^p_{ik}/P^w_i. The producer price is the ratio $P^c_{ik}/(1 + m_{ik})$, where P^c_{ik} is the consumer price of good k in country i, as taken from the OECD data, and m_{ik} is the margin for good k in country i, as taken from the national input–output table. The common world price is found by adding the international transport cost to the lowest export price in the sample. Finally, he uses a computable general equilibrium (CGE) model to assess the welfare effects of NTBs. Results show that OECD countries impose significant costs on themselves and on less developed countries.

In any case, an import price without the tariff is needed. The price used for the conversion has, in practice, a considerable impact on the value of the AVE. In spite of endogeneity problems, a unit value of imports can be used. Experience proves that it is extremely difficult to match the relevant data sets (trade and tariffs) because tariff lines are often set at a very detailed level (eight-digit level or more).

Gibson *et al.* (2001), working on a large sample of countries, convert all the specific tariffs using the unit value of world trade at the six-digit level whereas Bureau *et al.* (2000) and Jank *et al.* (2002) use a 3-year average unit value of imports or exports of the particular county at the eight-digit level. The former approach introduces a bias since it leads to some tariff peaks that are somewhat 'artificial' because a specific tariff for a given commodity is converted in an AVE using a price that reflects a much broader category.[7] Nevertheless, the latter approach is not necessarily superior because at the eight-digit level or higher only unit values of the imports of the particular country can be used (because of the lack of consistency in the classifications across countries beyond the six-digit level).

These examples show that both assumptions suffer from drawbacks but are nevertheless defendable and lead to very different estimates of AVEs. It is also worth mentioning the approach followed in the MAcMap database (Bouët *et al.*, 2004). Specific tariffs are converted in AVEs using the median unit value of worldwide exports originating from a reference group the exporter belongs to.[8]

MAcMap also attempts to solve the problems raised by the treatment of tariff-rate quotas. The proposed methodology is based on the idea that the calculation should reflect the marginal level of protection. Accordingly, three market regimes are considered depending on the level of the fill rate (if the fill rate is less than 90% – quota not binding – the inside quota tariff rate is chosen as the applied rate; in the 90%–99% range – quota assumed to be binding – a simple arithmetic average is used; if it is higher than 99% – quota binding – the applied rate is equal to the outside quota tariff rate).

3.3 *Equivalence Measures*

In principle, the effects of NTBs may be quantified by estimating the tariff that would produce the same overall impact. The problem is that the impacts of NTBs are multidimensional and there is no measure that gives an equivalence in all dimensions. An equivalence criterion must be established and the effects of NTBs quantified with respect to the dimension we are interested in. In this perspective, there is a growing literature using econometric models to estimate changes in prices, trade flows and economic performances due to the introduction of an NTB.

There exist several papers in the literature which have estimated the tariff equivalents using different econometric methodologies and data. Recent econometric models to estimate NTBs come in a number of varieties. According to Ferrantino (2006), a broad distinction can be made between price-based and quantity-based models: price-based models look for evidence that NTBs cause the domestic price of certain goods to be higher than it otherwise would be whereas quantity-based models look for evidence that NTBs cause trade in certain goods to be smaller than it otherwise would be.

Price-based methods aim to identify the extent to which higher domestic prices may be attributable to NTBs and correct other factors that may influence prices but are not due to NTBs. In order to explain the systematic reasons for international price differences more carefully, many models exploit the so-called Balassa–Samuelson effect which explains the higher absolute price level in rich countries with the higher levels of productivity in tradables relative to non-tradables.

Andriamananjara *et al.* (2004), for example, find that much of the international deviation in goods prices can be explained by deviation in the prices of non-tradable services. Moreover, data on NTBs from both TRAINS and Donnelly and Manifold (2005) databases are used to identify countries and products for which NTB effects might be expected and estimates are generated for these effects. In the same vein, Dean *et al.* (2003) use retail prices (considered to be composites of the prices of imported and domestically produced goods, including distribution costs and transport costs) and impose some simplifying assumptions to the theoretical model for estimating a tariff equivalent of the NTBs which varies across sectors and regions.

Price equivalents are often used to quantify the impact of sanitary and phytosanitary (SPS) regulations and other technical barriers to trade (TBT) on market equilibrium and trade (see, for example, Calvin and Krissoff, 1998). Calvin and Krissoff provide a tariff equivalent of phytosanitary barriers in the Japanese apple market regarding the risk of contamination by fire blight. They use the law of one price under a homogeneous commodity assumption (arbitrage condition) to calculate the tariff equivalent of SPS barriers affecting apple imports in Japan to avoid damages from fire blight. Yue *et al.* (2006) derive a revamped tariff-equivalent estimate of a TBT by relaxing the homogeneous commodity assumption and accounting explicitly for commodity heterogeneity and perceived quality of substitutes and trade costs.

The tariff equivalent of the TBT, TBT_T, is a function of the relative cost of the two goods (p_{k1} and p_{k2}), their volumes (Q_{k1} and Q_{k2}), the elasticity of substitution (σ), the preference parameter (α), international trade costs (IT_R), internal transaction and transportation costs (T_R) and border tariff (*tariff*):

$$TBT_T = p_{k1}\frac{1-\alpha}{\alpha}\left(\frac{p_{k1}}{p_{k2}}\right)^{1/\sigma} - p - IT_R - tariff - T_R \qquad (6)$$

where price p represents the price/cost of the imported good. Equation (6) nests the conventional technique that assumes perfect substitutes leading to the TBT in order to explain the differential between the domestic price and international price adjusted for transportation. More recently, Yue *et al.* (2006) extend this approach relaxing the homogeneous commodity assumption.

The other approach for measuring NTBs is to model the determination of quantity rather than price and then include an index of trade restrictiveness in a quantity equation. Quantity-impact measures focus on changes in the volume of imports and domestic production caused by various non-tariff policies. As for price comparison measures, it is hard to obtain appropriate data to compute the exact quantitative impact of an NTB.

In a study of trade liberalization in Africa, Nash (1993) estimates changes in the ‘tariff equivalent’ of multiple restrictions on imports in a number of developing countries. Nash derives an estimate of changes in the tariff equivalent of all restrictions on imports using the import demand function:

$$M = a + bY + c[P_M E(1 + t)] \quad (7)$$

where M is imports (in quantity, not value, terms), Y is income, P_M is import price in dollars, E is the real exchange rate and $1 + t$ is the 'tariff equivalent' of import restrictions, i.e. a measure of the increase in domestic prices that would be needed to reduce import demand to the same degree as the import restrictions.[9] If data are available for imports, income, import prices and the exchange rate and the elasticities can be estimated (or assumed on the basis of previous estimates for other developing countries), the change in $1 + t$ can be computed.

The estimate of effects of trade barriers on quantities can in turn be converted into an effect on prices by use of an assumed or estimated price elasticity of demand. In a recent study, Kee *et al.* (2004b) derive country-by-country quantity impacts of NTBs by analysing trade data econometrically. They provide AVEs of NTBs for 104 developing and developed countries and consider core NTBs (price and quantity control measures) and non-core NTBs (according to UNCTAD's (2005) classification), namely technical regulations and monopolistic measures such as single channel for imports as well as agricultural domestic support. They do not include other NTBs because of the lack of data. Estimates are provided at the tariff line level (HS6-digit), following Leamer's (1990) approach which compares actual imports with trade flows predicted according to country-specific factor endowments. Then quantity impacts are converted into price equivalents using import demand elasticities estimated at the tariff line level (Kee *et al.*, 2004a).[10]

In principle, then, the effects of NTBs can be detected using either price data or quantity data. In practice, the relative abundance and degree of detailed data on trade flows makes them attractive for analytical purposes. On the other hand, trade data are often value rather than pure quantity data and care needs to be taken in the microeconomic assumptions used to interpret the results. Another argument for using trade flow data is based on the fact that NTBs have a first-order impact on the level of imports but only a second-order effect on domestic prices. However, the disadvantage of using quantities is that there are two sources of statistical uncertainty: from the analysis of trade flows itself and from the separate analysis in which the elasticities (necessary in order to transform the effects on trade flows into AVEs) were obtained (Ferrantino, 2006).

Knowledge of the types of NTBs that are most likely to produce increases in trade or economic welfare upon their removal would be very useful. The single price gap appears to reflect the cumulative effects of all policies. Econometric methods are promising in this respect although it is important to remember that the presence of restrictive or inefficient policies tends to be correlated. For example, Ando and Fujii (2001) estimate the tariff equivalents of both core NTBs (price and quantity control measures) and non-core NTBs (automatic licensing measures, monopolistic measures and technical measures, based on the UNCTAD classification system) in 13 APEC economies, focusing on price differentials between the c.i.f. price of imported goods and the domestic producer price of the domestic substitutes at the four-digit level. They econometrically estimate a relationship between overall tariff equivalents and by-type frequency ratios (with other control variables) and use this estimated relationship to break the overall tariff equivalents down into five types: price control measures, quantity control measures, auto-licensing measures, monopolistic measures and technical measures. Their estimates reveal that developed countries with low general tariffs or low preferential tariffs under a number of free trade agreements significantly protect domestic industries by non-core measures such as technical measures. On the other hand, developing countries do not heavily apply NTBs to their commodities except agriculture and food processing sectors.

Finally, it is worth mentioning a recent paper by Sharma (2006) which uses a standard partial equilibrium method to quantify equivalent quotas for deviations in tariff cuts, or rather for the portion of the tariff that is not reduced as per a general tariff cutting formula. It is equal to

$$\text{quota} - \text{equivalent of tariff deviation} = \Delta M/M_0 = -\eta_m^*[\Delta t/(1+t_0)] \qquad (8)$$

where $\Delta M/M_0$ is percentage change in import, η_m is import demand elasticity, Δt indicates change in tariff or deviation in tariff cut and t_0 is the tariff rate before tariff cuts. Interestingly, a similar mechanism has been proposed by the EU in the present WTO negotiations in order to compute the commitments that should be undertaken for the so-called ‘sensitive products’.

4. Aggregation Across Products

With several products, the question arises as to how average quantity restriction (or price increase) represents the restrictiveness of a system. As we will see below, the problem of calculating a scalar index that aggregates the levels of protection granted to the producers of several commodities is a particularly difficult index number problem.

4.1 *Incidence Measures*

Incidence measures are constructed from data on the actual barriers themselves. Typical examples of this typology are measures used to evaluate the level (or dispersion) of tariffs through the direct observation of the policy instruments. The common ways to assess the protective effect of tariffs are the simple average to capture the overall level of tariffs and the standard deviation to measure the dispersion of tariffs as the spread or distance of most observations from the arithmetic mean.

An unweighted average tariff has obvious disadvantages. First of all, tariff schedules sometimes have distributions that are highly skewed so that the mean or the standard deviation is not the most appropriate summarizing measure. In this case, the mean may misrepresent the central tendency of the data and the most representative measure could be the median which measures the midpoint of the tariff schedule’s distribution. When a country’s tariff schedule is normally distributed, the mean and median tariffs would be very close but, when the tariff schedule is highly skewed, both the mean and median give useful information. The cases of high mean with low median (or low mean with high median) suggest extremely high (or low) levels of protection for a few specific commodities although most tariff lines are low (or high).

The average tariff rate is clearly an imperfect measure of trade restrictiveness since simple averages of tariff lines ignore the different economic importance of the product lines under consideration. The dispersion of the tariff structure is at least as important, in terms of impact, as its average level. An uneven tariff structure, as a matter of fact, can result in more severe trade distortions than a slightly higher but more balanced overall level of protection. This has led many practitioners to supplement averages of tariff rates by incidence measures of tariff dispersion such as the unweighted standard deviation or the coefficient of variation of tariffs (CV), defined as the ratio of the standard deviation to the mean:

$$CV = \frac{\left(\frac{1}{K}\sum_{k=1}^{K}(t_k - \bar{t})^2\right)^{\frac{1}{2}}}{\bar{t}} \tag{9}$$

where CV is the coefficient of variation, the numerator is the standard deviation of tariffs and $\bar{t}$ is the average tariff.

Another example of incidence measure is the tariff wedge. It represents the simplest measure of tariff escalation that consists in protecting processed products at a higher level than primary products and represents a possible consequence of tariff dispersion. The tariff wedge (τ_{yx}^{w}) is given by the difference in nominal tariffs between the output commodity y and the input commodity x:

$$\tau_{yx}^{w} = \tau_y - \tau_x \tag{10}$$

where τ_y is the AVE of the tariff on the output commodity y and τ_x is the AVE of the tariff on the input commodity x. Nominal tariff escalation occurs when $\tau_{yx}^{w} > 0$. An FAO study by Lindland (1997) examines the impact of the Uruguay Round on tariff escalation in agricultural products in three major agricultural markets (EU, Japan and USA). As a result of the Uruguay Round tariff concessions, more than 80% of nominal tariff wedges between raw materials and their processed products appear to have decreased in nominal terms.

The main limitations of this approach are that nominal tariff wedges do not fully represent the intensity of protection caused by the tariff structure and do not provide information on the impact of tariffs on the value added of processed products. Furthermore, they compare nominal tariffs of final output with only one input so that they cannot be meaningfully applied to fabrication processes involving multiple inputs and/or multiple outputs.[11] Consequently, when there are several different protected agricultural inputs, it is difficult to confirm the existence of tariff escalation. Moreover, since tariff wedges do not take into account the value added, they cannot be compared across commodities (Lindland, 1997; Antimiani, 2004; Antimiani and Salvatici, 2005).

Finally, a subjective measure is the IMF's trade restrictiveness index (TRI) that consists of three components: the overall trade restrictiveness index, the tariff restrictiveness rating (TRR) and the NRR.[12] The TRR consists of a five-point scale based on the simple unweighted average of a country's tariff rates. The rating was designed so that broadly equal numbers of countries are represented in each of the five categories. By combining the non-tariff rating with the TRR, the IMF elaborates an overall trade restrictiveness rating that is a 10-point scale.

4.2 *Outcome Measures*

One of the most commonly used approaches for measuring the degree of protection is the weighted average rate of tariff charges, τ^a, using as weight the respective share in imports valued at border prices.[13] The average tariff can be written as a weighted average of tariff rates:

$$\tau^a = \sum \omega_k^* \tau_k \tag{11}$$

where τ_k (equal to t_k/P_k^*) is the *ad valorem* tariff rate on good k and the weights ω_k^* are based on import volumes M_k valued at world prices P_k^*:

$$\omega_k^* = \frac{M_k P_k^*}{\sum M_k P_k^*} \tag{12}$$

Despite its convenience (it is intuitive and easy to calculate), the trade-weighted average tariff immediately runs into several difficulties. The most obvious shortcoming is the already mentioned 'endogeneity bias': highly taxed imports tend not to be imported (Anderson and Neary, 2005). Using imports as weights leads to an underestimation of the protection level of a country. The negative correlation between the level of tariffs and the level of imports implies that a high (low) tariff generates limited (large) imports and its contribution to the overall protection is then reduced (increased). Import-weighted averages then tend to understate the significance of the very tariffs that have been most successful in reducing imports. Furthermore, tariffs have greater effects on trade volume when they apply to imports in relatively elastic demand but it is precisely these goods whose weights fall fastest. If there is a positive correlation between import demand elasticities and tariff levels, high tariffs receive a low weight whereas low tariffs receive a high weight.

In order to avoid this problem, several authors have suggested alternative weighting schemes. For example, production shares ensure that highly protected commodities produced in large amounts get appropriately large weights but this method can result in an upward bias because many factors other than tariffs affect agricultural production levels (Andriamananjara and Nash, 1997). In addition, production data at the tariff line level is rarely available.[14]

In bilateral comparisons, a useful technique for assessing the real level of tariff protection is to use averages that take into account the proportional relevance of sensitive products. Gehlhar and Wainio (2002) reconstruct tariffs for the food processing sectors using a weighting scheme that takes the composition of exporters' trade into account. It represents an effective and practical way to combine large numbers of trade flows and tariffs in a simple average, putting the greatest emphasis on the tariffs in the importing country that are of the greatest importance to the exporting partner. More specifically, this is done by weighting each of the importing country's tariffs by the proportion of the exporting country's total exports accounted for by each tariff line within a given commodity category (Jank *et al.*, 2002).

In the same vein, bilateral indexes can be used in order to highlight a specific country's revealed comparative advantage, as measured by its major export basket against each major partner's border protection. Bilateral tariffs faced if all exports went to each destination were first introduced by Sandrey (2000) in order to compute the relative tariff ratio (RTR) index. The RTR is simply the ratio of two respective bilateral tariffs, computed assuming that all trade takes place between the two partners. Using the structure of overall exports of a country to weight the importing countries, tariffs may have some legitimacy for bilateral comparisons. However, the RTR does not allow for consistent (i.e. transitive) comparisons of market access.

Global imports (exports) can be used as weights but they may constitute import structures that are radically different from those in the region being considered. Bouët *et al.* (2004) retained the option of weighting the imports of a country by those of a reference group the country belongs to in the aggregation of tariffs from the MAcMap-HS6 database.[15] These authors reduce the endogeneity bias in the aggregation procedure through a weighting scheme based on groups of countries ('reference groups'). Accordingly, the weighting of tariffs across products and across exporters is not based on bilateral trade flows but on the exports toward the reference group the importer belongs to. By substituting the reference group by the importer, the endogeneity bias is decreased. The world is divided into five reference groups that correspond to different levels of development. When aggregating across importers for a given exporter and a given product, weights are normalized by the share of total imports from this exporter in total imports of its reference group in order to account for the fact that exporters and reference groups may differ in size.

For outcome measures as for incidence measures, practitioners often supplement weighted averages of tariff rates by measures of dispersion that incorporate some weighting schemes. However, this has little to recommend it. First, qualifications must be made in interpreting changes in tariff dispersion. More generally, there is no satisfactory rule for combining the measures of average and dispersion to yield a measure which might be comparable across countries or across time (Anderson and Neary, 2005).

Another well-known measure of trade protection is the effective rate of protection which takes into account the effects of tariffs on both inputs and outputs. There are two ways to measure effective protection and therefore assess how much the final product is protected compared with the raw materials. The concept of the effective rate of protection was developed by Balassa (1965) and Corden (1966) to measure the increase in value added in an industry under protection compared with what value added would be under free trade. In other words, it is the percentage increase in value added per unit in an economic activity which is made possible by the tariff structure compared with the situation in the absence of tariffs:

$$pr_y = \frac{VA_y - VA_y^*}{VA_y^*} \tag{13}$$

where pr_y is the effective protective rate for activity y; VA is value added computed with distorted prices (i.e. including tariffs) whereas VA^* is value added at world prices. It depends not only on the tariff on the final product but also on the input coefficients and the tariffs on the inputs.

On the other hand, Leith (1968) defines effective protection as the proportional change in the 'price' of the value added due to the tariff structure. Bruno (1979) and Woodland (1982) provide microeconomic foundations for Leith's approach. This approach measures protection on a value-added basis rather than on the basis of the final price of a product and thus takes the level of protection on intermediate inputs as well as the final product into account. Assuming that one unit of output y necessitates the use of a_{xy} quantity of inputs x, the value added per unit of output at free trade prices (VA_y^*) and in presence of tariffs (VA_y) is equal to

$$VA_y^* = P_y^* - \sum_x a_{xy} P_x^* \tag{14}$$

and

$$VA_y = P_y^*(1 + \tau_y) - \sum_x a_{xy} P_x^*(1 + \tau_x) \tag{15}$$

where P_y^* and P_x^* are the nominal prices per unit of output y and input x at free trade prices respectively; τ_x and τ_y are the nominal tariffs in AVE of input x and output y, respectively; q_{xy} is the physical input x per unit of output y so that $a_{xy} = q_{xy}^* P_x / P_y a_{xy}$ is the share of input x in cost of y at free trade prices. Then the effective rate of protection pr_y can be rewritten as

$$pr_y = \frac{\tau_y - \sum_x a_{xy}\tau_x}{1 - \sum_x a_{xy}} \quad (0 < a_{xy} < 1) \tag{16}$$

If a constant coefficient (i.e. Leontief) technology is assumed, the share of the raw material in a final product is kept constant regardless of relative prices. In this case the Leith and Corden measures are equal. Equation (16) shows the relationship between a nominal tariff wedge and the effective rate of protection. When $t_y > t_x$ (then $pr_y > \tau_y > \tau_x$), tariff escalation takes place and pr_y increases with the increase in a_{xy}; when $\tau_y < \tau_x$ (then $pr_y < \tau_y < \tau_x$) and $\tau_y < a_{xy}\tau_x$ (then $pr_y < 0$), tariff de-escalation occurs and pr_y decreases with the increase in a_{xy}; when $\tau_y = \tau_x$ (then $pr_y = \tau_y = \tau_x$), there is a tariff parity and pr_y is not affected by change in a_{xy}.

The effective rate of protection overcomes the limitations of tariff wedges as a way to measure tariff escalation since it focuses the attention on gross outputs of sectors taking account of the role of intermediate inputs. The major problem in terms of empirical application, compared with the nominal tariff wedge, is that it needs accurate data on prices and technical input–output coefficients which are not always available.

The effective rate of protection makes a distinction between protection on the primary input and on the final product in order to isolate the protection on the value added component of a processed product. However, the above definition has a number of drawbacks and it has been seen that in a general equilibrium framework it does not provide an accurate measure of the attraction of primary resources in one sector (Bhagwati and Srinivasan, 1984). For instance, the ‘endogeneity bias’ may lead, among other things, to an underestimation of the effective protection in cases of ‘escalated’ tariff structures (Pritchett and Sethi, 1994). Nonetheless, despite its limitations, the effective rate of protection remains one of the most common indicators to evaluate trade policy: ‘Effective protection concept is the ranch house of trade policy construction – ugly but apparently too useful to disappear’ (Anderson, 1998b).[16]

Outcome measures can also be computed using counterfactual rather than observed weights. For example, Barro and Lee (1994) compute a measure of tariff restriction (*freetar*) based on the import weighted tariff rates on intermediate inputs and capital goods (*owti*), constructed from UNCTAD data, and a measure of ‘free trade openness’ (*freeop*), constructed from a regression based on the physical dimensions of each country and the average distance to capitals of the world 20 major exporters weighted by the values of bilateral imports:

$$freetar = freeop * \log(1 + owti) \tag{17}$$

The underlying intuition is that distortionary effects of trade restrictions should be larger in economies that, in the absence of trade restrictions, would be more exposed to trade.

As far as the effective protection is concerned, Bureau and Kalaitzandonakes (1995) estimate a flexible, functional form allowing for substitution between outputs and inputs. The estimation they propose requires a functional form that accounts for input substitutions and thus raises the problem of data for econometric estimates: practical difficulties might offset some of the theoretical advantages.

In order to characterize changes in the distribution of tariffs, Anderson and Neary (2007) introduce generalized or substitution-weighted tariff moments. These are equal to weighted moments where the weights are elements of the substitution matrix S (i.e. the Hessian of the trade expenditure function that will be introduced in the next section) normalized by the domestic prices.

Define the *ad valorem* tariff rate on good k relative to the domestic price base as

$$T_k \equiv \tau_k / P_k = \left(P_k - P_k^*\right) / P_k \qquad 0 \le T_k < 1 \tag{18}$$

The T_k are related to tariff rates defined with respect to world prices ($t_k = \tau_k / P_k^*$) by

$$T_k = \tau_k / (1 - \tau_k) \tag{19}$$

Anderson and Neary (2007) define two generalized moments of the tariff structure. The first moment is the generalized average tariff ($\bar{T}$):

$$\bar{T} = \sum_k \sum_z S_{kz} T_z \tag{20}$$

where S_{kz} denotes the individual elements of the substitution matrix. The second moment is the generalized variance of tariffs (V):

$$V \equiv \sum_k \sum_z S_{kz}(T_z - M(T))^2 \tag{21}$$

where

$$M(T) = \sum_k \sum_z S_{kz}(T_z - 1) \tag{22}$$

Although generalized moments do not have an interpretation in themselves, they do provide valuable insights into assessing the effects of changes in actual tariffs on welfare and import volume. Anderson and Neary (2007) show that the effects on welfare and import volume of a change in tariffs are fully described by their effects on the generalized mean and variance of tariffs.

4.3 *Equivalence Measures*

In order to introduce the equivalence measures, we first recall how the effects of trade policy can be expressed using the description first provided by Dixit and Norman (1980) and widely used since then (Anderson, 1994; Feenstra, 1995). The focus is on economic efficiency, defined in terms of the welfare of a representative agent. Distributive issues are ignored and protective purposes are set exogenously by the government which returns its net revenues from trade distortion to the agent. It makes no essential difference whether imports are for final consumption or intermediate input use nor does it matter whether export as well as import trade policies are considered.

On the other hand, assuming a small economy with perfect competition and constant returns to scale does not allow for terms of trade gains due to the trade policies. In other terms, we focus on the deadweight loss from distorting production and consumption decisions, ignoring possible gains from improving the terms of trade or from shifting profits between countries due to changes in the scale of firms (Feenstra, 1995).

Let the index k denote goods $k = (1, \ldots, K)$ that are sold at the international price vector $P^* = (P_1^*, \ldots, P_K^*)$ and at the domestic price vector $P = (P_1, \ldots, P_K)$. The vector χ includes all the variables assumed exogenous such as the world prices ('small country assumption') or the factor endowments. The optimal behaviour of the representative agent can be expressed through the trade expenditure function $E(P, U, \chi)$, obtained as the difference between the consumer's expenditure function $e(P, U)$ and the gross domestic product function $g(P, \chi)$. By making use of the properties of duality, we know that

1. the derivatives of the expenditure function with respect to prices equal the levels of consumption,
2. the derivatives of the gross domestic product function with respect to prices are the economy's general equilibrium net supply functions[17] and
3. the trade expenditure function is homogeneous of degree one in prices and its derivatives with respect to prices are the compensated import demand functions m_k (P, U, χ) which are homogeneous of degree zero in prices.

Given this structure of supply and demand, the other element of the model is provided by the external budget constraint. The constraint is expressed through the balance of trade function $B(P, U, \chi)$ that summarizes the three possible sources of funds for procuring imports: earnings from exports, earnings from trade policies (G) and international transfers. Assuming that the latter are equal to zero and that tariffs (vector t) are the only trade policy, we get

$$B(\cdot) = G - E(\cdot) = 0 \tag{23}$$

Total differentiation of the external budget constraint (23) using the small country assumption ($\mathrm{d}P = \mathrm{d}t$) implies

$$B_P \mathrm{d}U + B_P \mathrm{d}P = 0 \tag{24}$$

The first term ($B_P\mathrm{d}U$) is the change in net trade expenditure at constant prices that could take place, for example, as a consequence of a gift from abroad. The second term ($B_P\mathrm{d}P$) is the marginal cost of tariffs which is positive if tariff increases are inefficient. This is quite an intuitive assumption but it should not be taken for granted, even if we have ruled out possible gains due to imperfect competition or terms of trade. In partial liberalization, as a matter of fact, cross-price effects can make the marginal cost negative.

According to Anderson and Neary (1996), a general definition of a policy index is as follows: depending on a pre-determined reference concept, any aggregate measure is a function mapping from a vector of independent variables – defined according to the policy coverage – into a scalar aggregate. Consequently, the elements that define a theoretically consistent policy index of trade restrictiveness include the following:

1. the *policy coverage* (e.g. tariffs, import quotas, border and domestic policies, etc.);
2. the *reference point* for the 'equivalent impact' we are interested in (e.g. iso-welfare measures, iso-income measures, etc.) and
3. the *scalar aggregate*, i.e. the policy instrument into which the policy measures covered are translated (e.g. tariff-equivalent measures, subsidy-equivalent measures, quota-equivalent measures, etc.).

Bach and Martin (2001) firstly proposed a tariff aggregator that keeps expenditure constant. Anderson and Neary (2005) call it the 'true average tariff' (τ^δ) and define it as

$$\tau^\delta \colon E[(1+\tau^\delta)P^*, u^0] = E^0 = E(P^0, u^0) \tag{25}$$

where E^0 is trade expenditure in the tariff-distorted equilibrium. Equation (25) states that τ^δ is the uniform tariff that would induce the same level of trade expenditure at the initial level of utility as the actual vector of initial tariffs.

Like the trade-weighted average tariff, the true average tariff can be written as a weighted average of individual tariff rates with the crucial difference that weights allow for substitution in import demand. Drawing on the literature on the cost of living, weighting tariffs by existing import values is analogous to a Laspeyres price index which uses initial period weights whereas weighting by hypothetical import values under free trade is analogous to a Paasche price index using terminal period weights. Consequently, the Fisher ideal index, given by the geometric average between the Laspeyres and Paasche indexes, would represent an exact price index for a linear, Leontief or quadratic function.

Cline's 'adjusted import weighting' (2002) follows this line of reasoning in order to get an appropriate measure of protection. He uses an average between the observed import level and a measure of the import values that would occur if protection were removed as weights. The free trade import volume (M_1) equals the original volume (M_0) plus the change implied by the removal of the tariff t according to the price elasticity of the import demand (α):

$$M_1 = M_0 + M_0\left(-\alpha\left[\frac{-t}{1+t}\right]\right) \tag{26}$$

In practice, Cline introduces several simplifying assumptions: on the one hand, the absolute value elasticity of the import demand functions is assumed to be equal to 1 and, on the other, the weights are averaged according to a simple mean rather than using the geometric average corresponding to the Fisher 'ideal' price index. Accordingly, the adjusted import base M^* is given by

$$M^* = \frac{M_0 + M_1}{2} = \frac{M_0}{2}\left(\frac{2+3t}{1+t}\right) = M_0\left(\frac{1+1.5t}{1+t}\right) \tag{27}$$

Then, the Cline's weighted average tariff, t^*, is equal to

$$t^* = \sum \phi_k t_k \tag{28}$$

where t_k is the tariff rate in category k and the weights ϕ_k are calculated as

$$\phi_k = \frac{M_k\left(\frac{1+1.5t_k}{1+t_k}\right)}{\sum_k M_k\left(\frac{1+1.5t_k}{1+t_k}\right)} \tag{29}$$

and M_k is the value of imports in category k.

Following a more rigorous approach, Bach and Martin (2001) are able to obtain a closed-form solution for the expenditure tariff aggregator. Assuming a constant elasticity of substitution (CES) functional form for the trade expenditure function, with all domestic prices equal to 1 in the base equilibrium, the true average tariff is given by

$$\tau^{\delta} = \left(\frac{1 - \beta^{\delta}}{\sum_{k=1}^{K} \beta_k (1 + t_k)^{\sigma - 1}} \right)^{\frac{1}{1-\sigma}} - 1 \tag{30}$$

In the same vein, Manole and Martin (2005), assuming separability between domestic and imported products, obtain a closed-form solution defined exclusively over a group of imported commodities (no domestic product):

$$\tau^{\delta} = \left(\sum_{k=1}^{K} \beta_k (1 + t_k)^{\sigma - 1} \right)^{\frac{1}{\sigma-1}} - 1 \tag{31}$$

The 'true average tariff' has some potential uses: because of the prevalence of the 'Armington assumption' in modern models, it is the appropriate index to use to aggregate tariffs across sub-sectors in partial equilibrium studies as well as in CGE models. However, the index itself is of relatively limited interest. Since it only focuses on private-sector behaviour (defined by the trade expenditure function) and ignores the government budget constraint, if a uniform tariff equal to τ^{δ} were imposed, the economy would not be in equilibrium (since the balance of trade would not equal its initial level).

Bach and Martin (2001) also propose a tariff aggregator that keeps tariff revenue constant (τ^R). Manole and Martin (2005) obtain, using the assumption of separability between domestic and imported goods, a closed-form solution for a CES tariff aggregator using tariff revenue as reference point:

$$\tau^{R} = \frac{\sum_{k=1}^{K} t_k (1 + t_k) \beta_k}{\left(\sum_{n=1}^{N} \beta_n (1 + t_k)^{\sigma - 1} \right)^{\frac{1}{1-\sigma}}} \tag{32}$$

where the β_n are value shares of imports at domestic prices and σ is the elasticity of substitution.

The trade restrictiveness index (TRI), developed by Anderson and Neary (1994), is a uniform tariff-equivalent, iso-welfare measure. In terms of policy coverage, for simplicity the following presentation only deals with tariffs. Although the inclusion of import quotas introduces some analytical complications – for example, in terms of how the quota rent is shared between the importing and exporting country (Anderson and Neary, 1992) – both price and quantity import restrictive policies can be included in the TRI, as well as domestic policies (Anderson *et al.*, 1995).

The TRI (Δ) is implicitly defined as the inverse of the uniform tariff factor (one plus the uniform tariff) which would compensate the representative consumer for the actual change in tariffs, holding constant the balance of trade:

$$\Delta(P^1, u^0; \chi^0) = \{\Delta | B(P^1/\Delta, u^0; \chi^0) = 0\} \tag{33}$$

If new tariffs are equal to zero, $1/\Delta - 1$ is the uniform tariff which is equivalent in efficiency to the original trade policy. More generally, $1/\Delta$ is the scalar factor of proportionality by which period 1 prices would have to be adjusted to ensure balanced trade when utility is at period 0 level. Note that this is not the same as introducing a uniform tariff rate (except when we deal with a full liberalization).

Paralleling Hicks, there are 'compensating variation' (the distance from the new policy to the old utility contour) and 'equivalent variation' (the distance from the old policy to the new contour) measures of the total trade restrictiveness. The TRI defined in equation (33) is a compensating variation type of measure since Δ is used to deflate period 1 prices in order to attain period 0 utility. The purpose of any compensating variation index number of border policies is to map consistently some alternative setting of tariffs and quotas into a uniform tariff and quota setting which supports the base level of utility. An 'equivalent (variation) TRI' (Δ^{EV}) can be defined

$$\Delta^{EV}(P^0, u^1; \chi^0) = \{\Delta | B(P^0\Delta, u^1; \chi^0) = 0\} \tag{34}$$

which would operate on period 0 prices in order to attain period 1 utility. The equivalent TRI is in principle superior because of its transitivity property but, since actual prices are not necessarily equal to a radial expansion of the free trade prices vector, it will not be generally defined in the move all the way to free trade. However, by the same token, it should be noticed that the 'compensating TRI' is not generally defined if we start from a situation of free trade. In this case, as a matter of fact, a radial contraction of the distorted prices is not necessarily equal to the free trade prices.

In order to obtain a better understanding of the definitions provided above, let us consider the consequences of trade liberalization of goods subject to a tariff. We define

P_1 = new (i.e. after trade reform) price,
π = counterfactual price that would restore utility to the old level and
τ = uniform (compensating) tariff rate.

Since $P_1(1 + \tau) = \pi$, if we assume a tariff decrease ($P_1 < \pi$), the uniform tariff factor $(1 + \tau)$ is greater than one. Furthermore, $1 + \tau = 1/\Delta$ means that the TRI is equal to $1/(1 + \tau)$. This implies that a reduction in trade distortions leads to $\Delta < 1$. In the case of linear import demand functions

$$m_k = \alpha_k - \beta_k P_k \tag{35}$$

we can derive an explicit formula for the welfare-equivalent uniform tariff (Feenstra, 1995):

$$\tau^{\Delta} = \left[\sum_k^K t_k^2 z_k \right]^{1/2} \tag{36}$$

where $z_k = P_k^{*2}\beta_k / \sum [P_k^{*2}\beta_k]$.

Comparing equation (36) with the trade-weighted average tariff τ^a in equation (11), the former is a mean of order 2, whereas the latter is an arithmetic mean. The TRI weights, then, correctly take into account the welfare cost of distortions as an increasing function of the mean and the variance of the individual tariff rates ('Harberger triangle effect').

The small country assumption is a convenient, though admittedly unrealistic, feature of the TRI. If tariffs do not influence world prices, they may enhance welfare by only improving the allocative efficiency within the country. Therefore, in a small country setting, we are able to gauge protection by the degree of a country's 'self-inflicted harm'. Since it is well understood that tariffs may impact domestic welfare by altering the world prices, the TRI can be considered a sort of upper bound in terms of the measurement of the overall welfare impact.[18] Salvatici (2001), Lloyd and MacLaren (2002) and Anderson and Neary (2005) relax the small country assumption and define a welfare-equivalent index with endogenous world prices.

Moreover, it is worth recalling that the TRI uses a balance of trade function approach to the evaluation of welfare change (i.e. a *compensation measure*) whereas most CGE models evaluate welfare changes using a *money metric of utility measure*. In a distorted economy, the results of these two approaches do not coincide (Anderson and Martin, 1993). Consequently, we need to redefine the index along the lines described by Salvatici (2001) in order to compute the TRI with a standard model.

Many applications of the TRI use a general equilibrium approach (Anderson and Neary, 1994, 1996; Anderson, 1995, 1998a; Bach and Martin, 2001; Salvatici, 2001; Lloyd and MacLaren, 2002). However, in order to use a disaggregated model that is able to capture the detail of actual protective policies, the structure of commodity and factor substitution must be significantly simplified.

In a partial equilibrium framework, the TRI may still be calculated provided a number of analytic shortcuts are taken. A partial TRI is defined over the trade policy instruments applicable to the markets of interest only. This implies two major simplifying assumptions. First, it is assumed that changes in trade policy do not affect the prices of other goods (prices of traded goods are held constant with the small country assumption). Indeed, if we are concerned with trade restrictions on a single industry, it seems reasonable to ignore changes in the prices of non-traded goods and factors if that industry accounts for a relatively small share of the GDP. The second simplifying assumption is that the goods to be considered are separable from others in excess demand.

Bureau and Salvatici (2004a, b) compute the TRI for the agricultural sectors included in the GTAP database for the QUAD countries (Canada, EU, Japan and USA). They use the index in order to compare the performance of different tariff cutting formulae and introduce some elasticity values taken from the literature into a CES import demand system. On the other hand, Kee *et al.* (2006) estimate the uniform tariff that keeps welfare constant given the observed tariff structure as well as the estimate of the NTBs AVEs (see Section 3.2) for 91 countries assuming linear import demand functions (see equation (35)). The econometric approach adopted allows work at the tariff line level and the standard errors of the estimates entering the calculation to be known: consequently, a standard error can be associated with the value of the TRI. The major drawback of this approach is that it ignores the general equilibrium of cross-price effects.

The proportional change in the TRI is a weighted average of the proportional changes in domestic prices. By total differentiation of equation (33) we get

$$\frac{B'_P}{\Delta}\mathrm{d}P - \frac{B'_P P}{\Delta^2}\mathrm{d}\Delta = 0 \tag{37}$$

Then

$$\frac{\mathrm{d}\Delta}{\Delta} = \sum_{i=k}^{K} \sigma_i \frac{\mathrm{d}p_i}{p_i}, \text{ with } \sigma_i = \frac{\partial B}{\partial p_i} p_i \Big/ \left(\sum\nolimits_{j=1}^{K} \frac{\partial B}{\partial p_j} p_j \right) \tag{38}$$

The weights in (38) turn out to be the proportions of marginal deadweight loss due to each tariff and they depend on the partial derivatives of the $B(.)$ function with respect to prices. Ordinarily, the marginal deadweight loss due to each tariff ($B_{Pk}\mathrm{d}P_k$) is positive since tariff increases are inefficient. However, this should not be taken for granted since cross-price effects can make it negative. The theoretical ambiguity about the sign of the weights in equation (38) means that the TRI is not completely free from counterintuitive, 'second-best' results.

Bureau *et al.* (2000) compute the rate of change of the agricultural TRI implied by the Uruguay Round Agreement on agriculture and compare it with the changes that would have been implied by different tariff-cutting formulae. The major weakness of this approach is that it relies on the knowledge of 'reasonable' elasticity parameters in order to compute the marginal cost of the trade distortion (see equation (38)). We must therefore rely on the computation of a hypothetical change in imports rather than focus on the observed change caused by the actual tariff. Although most of the empirical applications seem to show a low sensitivity of the TRI results to the elasticity values used in the computations, it remains true that the index relies heavily on elasticity parameters arbitrarily assumed or chosen between those available in the literature (O'Rourke, 1997).

The mercantilistic trade restrictiveness index (MTRI) relies on the idea of evaluating trade policy using trade volume as the reference standard. The interest is in the extent to which trade distortions limit imports from the rest of the world so that the aggregation procedure answers the following question:what is the equivalent uniform tariff that if imposed on home imports would leave aggregate imports unchanged?

The MTRI is defined by Anderson and Neary (2003) in terms of the uniform tariff τ^μ that yields the same volume (at world prices) of tariff-restricted imports as the initial vector of (non-uniform) tariffs. This can be expressed with import demand functions M, while holding the balance of trade function constant at level B^0:

$$\tau^\mu\colon M[P^\mu, P^0, B^0] = M^0(P^0, P^*, B^0), \text{ with } P^\mu \equiv P^*(1+\tau^\mu) \tag{39}$$

where P^* denotes the international prices (P_k^*) vector of the K goods $k = (1, \ldots, K)$, M^0 is the value of aggregate imports (at world prices) in the reference period and P^0 is the initially distorted price vector.

Define the scalar import demand as

$$M(P, P^*, B) \equiv \sum_{i=1}^{N} \sum_{k=1}^{K} P_{i,k}^* I_{i,k}^m(P, B) \tag{40}$$

where $I_{i,k}^m$ denotes the uncompensated import demand function of good k from country i. Accordingly, the MTRI uniform tariff τ^μ would lead to the same volume of imports (at world prices) as the one resulting from the uneven tariff structure, denoted by the $K \times N$ bilateral tariffs matrix T whose elements are $t_{i,k}$:

$$\sum_{i=1}^{N} \sum_{k=1}^{K} P_{i,k}^* I_{i,k}^m[P^\mu, B^0] = \sum_{i=1}^{N} \sum_{k=1}^{K} P_{i,k}^* I_{i,k}^m[P^0, B^0] \tag{41}$$

Kee *et al.* (2006) and Antimiani and Salvatici (2005) compute the MTRI uniform tariff bilaterally, to capture the trade restrictiveness that countries impose on each other. Accordingly, in equation (41), instead of summing over k and i, one would only sum over k to obtain a bilateral uniform tariff MTRI (τ_i^μ) defined as follows:

$$\tau_i^\mu : M_i\left[p^*\left(1 + \tau_i^\mu\right), B^0\right] = M_i^0 \tag{42}$$

where M_i^0 is the value of aggregate imports (at world prices) from country i in the reference period.

An extension of the MTRI definition allows the calculation of the index and relaxes the small country assumption (Anderson and Neary, 2005). Bilateral MTRIs for the EU in a model with endogenous world prices are computed by Antimiani and Salvatici (2005) using a multiregional CGE model (GTAP).

Even if the MTRI is a general equilibrium index, also in this case a partial equilibrium approximation can be defined. Bureau and Salvatici (2004b, 2005) assume that the overall basket of goods can be partitioned into K aggregates denoted $k = 1, \ldots, K$ and the utility function of the representative consumer can be written as

$$U = \varphi(u_1(x_1), \ \ldots \ , u_k(x_K)) \tag{43}$$

where φ is continuous, twice differentiable and strictly quasi-concave and the u_k are continuous, twice differentiable functions, homogeneous of degree one (Lloyd, 1975). When focusing on the K sectoral MTRIs, a convenient (albeit restrictive) assumption is to assume φ to be a Cobb–Douglas function (implying that the expenditure function is also a Cobb–Douglas one in prices with utility entering multiplicatively), in order to avoid the issue of allocation of consumer expenditure across sectors which, in general equilibrium models, is affected by tariffs within a particular aggregate k.

In partial equilibrium applications, the MTRI cannot be calculated unless there is a 'reference good' so that the price vectors refer to prices relative to this good.[19] Even if the MTRI is defined in terms of Marshallian demands, the import volume function is homogeneous of degree zero in the prices of traded goods because the tariff revenue is included in the budget constraint of the representative agent.

The empirical implementation by Bureau and Salvatici follows Bach and Martin (2001) and models import demand through a CES functional form. Kee *et al.* (2006), on the other hand, estimate the MTRI uniform tariff (calling it 'overall trade restrictiveness index') assuming linear import demands. In this instance, the import-volume-equivalent uniform tariff is defined implicitly by the equation (Anderson and Neary, 2005)

$$\sum P_k^*\left[\alpha_k - \beta_k\left(1+\tau^\mu\right)P_k^*\right] = \sum P_k^*\left[\alpha_k - \beta_k\left(1+\tau_k\right)P_k^*\right] \tag{44}$$

Solving for τ^μ gives

$$\tau^\mu = \sum z_k \tau_k \tag{45}$$

This has the same linear form as the trade-weighted average tariff τ^a but the same weights as the welfare-equivalent uniform tariff τ^Δ (see equation (36)).

In the same way as the TRI, a 'local approach' can be envisaged estimating changes in μ resulting from the different patterns of tariff reductions (Anderson *et al.*, 1995). Proportional changes in the indexes can be expressed as weighted averages of the proportional changes in domestic prices, i.e.

$$\frac{\mathrm{d}\mu}{\mu} = \sum_{k=1}^{K}\left(\frac{\dfrac{M}{P_k}P_k}{\sum\limits_{k=1}^{K}\dfrac{M}{P_k}P_k}\right)\frac{\mathrm{d}P_k}{P_k} \tag{46}$$

Bureau *et al.* (2000) compute the rate of change of the agricultural MTRI due to the implementation of the Uruguay Round Agreement both for the EU and the USA. These changes can be interpreted as follows. Due to the tariff reduction required by the multilateral commitments, there is a move from a protected structure ($P_k^0 > P_k^*$, $\forall k$) to a less protected structure where $P_k^0 \geq P_k^1 \geq P_k^*$, $\forall k$. In order to compensate for the change in the tariff structure, a uniform tariff surcharge (equal to the inverse of μ) must be imposed which raises prices to the point that the volume of imports is restored to its initial level (i.e. before the change in the tariff structure). This means that the reduction in market protection is signalled by a reduction in the MTRI.

Finally, it is worth mentioning that in addition to the MTRI other indexes based on the 'volume-of-trade' equivalence criterion can be conceived. Anderson and Neary (2005) propose the 'compensated MTRI', i.e. the uniform tariff that yields the same volume of trade as the initial tariff structure subject to the constraint that utility is held constant, and the 'uniform border barrier', i.e. the compensated MTRI uniform tariff that yields the same domestic value of international trade. Kee *et al.* (2006) focus on the distortions that the rest of the world imposes on each country export bundle using export value as the relevant metric. This is the 'market access overall trade restrictiveness index' which answers the following question: what is the uniform tariff that would leave exports of a country unchanged if imposed by all trading partners on its exports.

For effective protection, theoretically sound equivalence indexes have also been defined. Anderson (1998b) proposes a distributional effective rate of protection (DERP) of sector k (E_k) as the uniform tariff which exerts on the return to specific factor k an effect which is equivalent to the initial tariff structure. That is:

$$E_k = 1/D_k - 1 \tag{47}$$

where the uniform scaling factor (D_k) is defined implicitly as

$$D_k(P^1; P^0, v, \chi) \equiv \{D | g_k^\chi(P^1/D, v, \chi) = g_k^\chi(P^0, v, \chi)\} \tag{48}$$

The function D is the distance function applied in the tariff distorted price space. Accordingly, D_k is the uniform output price deflator which maintains profits in k constant. Since D is equal to the inverse of a uniform tariff factor, E_k is equal to the uniform tariff on distorted goods which has the same effect on the profits of sector k as the initial tariff vector.

In a special case, that of partial equilibrium with fixed coefficients of production, the formula implied by the new definition is identical to the usual effective rate of protection formula; with variable coefficients but still in partial equilibrium, the formula is a simple variant of the traditional effective rate of protection formula.

Sector-specific factor income changes are a product of two elements: the level of protection given to the sector (and this is what the traditional effective protection concept attempts to measure) and the rate at which the level of protection is translated into sector-specific factors' income. Differences in income changes across sectors arise from the differences in both elements of the product and the new concept gives a precise measure of effective protection in this context. In other words, the two concepts of effective protection and tariff escalation, even if correlated, are different because the latter refers 'only' to the tariffs, whereas the former takes into account the effects on the production function arising from the tariff structure.

Anderson (1998b) computes the DERP for US agriculture, whereas Antimiani *et al.* (2003) use this index to assess the effective protection granted to the EU agrifood sector. The latter application is implemented using a CGE model with endogenous world prices. Accordingly, Antimiani *et al.* follow up a suggestion of Anderson (1998b) relaxing the small country assumption in the DERP definition. If the vector P is a function of the tariff vector τ, equation (48) becomes

$$D_k(P^1; P^0, v, \chi) \equiv \left\{D | g_k^\chi\left[P^1\left(\tau^1/D\right), v, \chi\right] = g_k^\chi\left(P^0, v, \chi\right)\right\} \tag{49}$$

The same approach can be used to define an index which is able to measure the impact of protection on the ability of sectors to compete with other industries in factor markets: the output effective rate of protection (OERP). This index is based on the uniform tariff on all distorted sectors which produces the same level of output, sector by sector, as does the initial differentiated tariff structure (Anderson, 1998b). Output variations across sectors reflect both the structure of protection and differences in the production structure of the economy. The two questions ‘how much protection is given’ and ‘how much does supply change as a result’ are distinct and the OERP gives a precise answer to the latter.

The OERP pr_k of sector k in general equilibrium is defined as the uniform tariff which exerts on the output of k an effect which is equivalent to the initial tariff structure. That is:

$$pr_k\colon Y_k\left[P_k^{pr}, w^{pr}\left(p_k^{pr}, v\right)\right] = Y_k^0\left(P^0, w^0\right), \text{ with } P_k^{pr} \equiv P_k^*\left(1 + pr_k\right) \quad (50)$$

where Y_k is the k supply function and w is the vector of competitive factor prices (w is a function of the price vector P and of the fixed factor supply v).

The previous definition is based on the ‘small country’ assumption. If we want to allow for endogenous world prices, we need to define the vector P^* as a function of the tariff vector (t). Equation (50) becomes

$$\begin{aligned} pr_k^w\colon Y_k&\left[\left(1 + pr_k^w\right)P_k^*(t), w^{pr}\left(\left(1 + pr_k^w\right)P_k^*(t), v\right)\right] \\ &= Y_k^0\left[\left(1 + t_k^0\right)P_k^*(t), w^0\left(\left(1 + t_k^0\right)P_k^*(t), v\right)\right] \end{aligned} \quad (51)$$

where pr_k^w is the OERP uniform tariff with endogenous world prices. The latter definition is used by Antimiani and Salvatici (2005) in order to compute the index for the EU sectors.

Some policies such as import quotas are easier to handle in the volume dimension since this would not require the conversion to a price measure. Quantity-based equivalent measures represent a measure of trade policy based on the deviations of observed trade flow from what they would have been had the economy been trading freely.

The coefficient of trade utilization (CTU) originally introduced by Debreu (1951) is implemented by Anderson and Neary (1990) as the uniform contraction factor applied to free trade quantities which is equivalent in welfare to the actual quota vector. In order to define the CTU, Deaton’s (1979) distance function concept is used and the index takes on the value one if and only if the actual resource utilization is optimal (free trade). Anderson and Neary (1990) show under what conditions the Debreau coefficient is a reliable welfare measure for a one-consumer economy. Anderson (1991) defines a partial CTU for trade reform in one sector and applies it to cheese.

Related to the CTU is the trade restrictiveness quantity index (TRQI) proposed by Chau *et al.* (2003) which also adopts domestic welfare as the reference point. The definition of the TRQI combines a production inefficiency index and a consumption inefficiency index. Regarding output inefficiency, the Paasche quantity index (Q_O^P) measures the maximum GDP divided by the observed net supply, evaluated at world prices (P^*):

$$Q_O^P(P^*, y^*, y, v) = \frac{\sum_{i=1}^{M} P_i^* y_i^*}{\sum_{i=1}^{M} P_i^* y_i} = \frac{g(P^*, v)}{P^* y} \quad (52)$$

Turning to consumption inefficiency, the Paasche quantity index (Q_C^P) measures the minimum expenditure divided by the observed consumption vector, evaluated at international prices (P^*):

$$Q_C^P(P^*, x^*, x, u) = \frac{\sum_{i=1}^{M} P_i^* x_i^*}{\sum_{i=1}^{M} P_i^* x_i} = \frac{e(P^*, u)}{P^* x} \tag{53}$$

The TRQI captures any policy induced inefficiencies in a small open economy combining the two previous indexes:

$$TRQI = Q_O^P / Q_C^P \tag{54}$$

By the definition of the revenue and the expenditure functions, $Q_O^P \geq 1$ and $Q_C^P \leq 1$. Hence, the TRQI takes on values between 1 and $+\infty$. Changes in the TRQI depend on the changes in the distorted producer and consumer prices and the relative impact of these changes in turn depends on the own- and cross-price elasticities, weighted by their shares in GDP. It is worth noting that the TRQI, even if it is essentially the 'dual' of the TRI, enjoys some distinctive properties. For example, being homogeneous of degree 0 in any one of the price vectors, it is independent of the choice of the *numeraire*.

In terms of empirical applications, the compelling feature of the TRQI is its relationship to the efficiency measurement literature. This means that several well-established tools of efficiency measurement could be readily used in order to estimate the TRQI: Bureau *et al.* (2002), for example, estimate the production component of the TRQI to evaluate the effects of EU agricultural policies using a parametric frontier model.

Efficiency measures such as the TRI or the TRQI are defined on the basis of the distance from an arbitrary point in the tariff or quantity space to an arbitrary general equilibrium utility contour. However, the fact that welfare-equivalent indexes are related to the total welfare cost does not imply that they convey the same information as the cost of protection measures. Welfare costs do not permit comparisons over space and time. Unscaled welfare losses would be biased upward for large countries in cross-country comparisons and for later periods in intertemporal comparisons. As a result, several varieties of scale have been attempted such as fractions of national income or trade expenditure. However, this biases the measure downward in cross-country comparisons for less open economies.

All the indexes discussed so far range from 0 to $+\infty$. We may want to define indexes of trade restrictiveness on the continuum of the closed interval [0, 1] with well-defined end points: 0 when there is no international trade and 1 when there is completely free trade.

Several measures which have these properties are obtained by Lloyd and MacLaren (2002) taking transformations of τ^{Δ}. One is the following measure:

$$L = 1 - \frac{\tau^{\Delta}}{\bar{\tau}^{\Delta}} \tag{55}$$

where $\bar{\tau}^{\Delta}$ is the uniform tariff rate that would eliminate international trade with other countries: in other terms, $\bar{\tau}^{\Delta}$ is the maximum value of τ^{Δ} in the hypothetical situation in which all trade ceases. By construction, $L \in [0, 1]$.

Another possible transformation suggested by Lloyd and MacLaren (2002) is

$$M = \frac{1}{\left(1 + \tau^{\Delta}\right)^{\lambda}} \qquad \text{where } \lambda > 0 \tag{56}$$

$M \in [0, 1]$ and the use of higher powers makes the measure move up and down the unit interval more rapidly as τ varies.

A third measure proposed by Lloyd and MacLaren (2002) is

$$N = \frac{Q}{\tilde{Q}} \tag{57}$$

where Q is the index of the volume of trade in the current situation and $\tilde{Q}$ is the index of the volume of trade in the (hypothetical) free trade situation. As the volume of trade in a restricted trade situation is lower than in the free trade situation, $N \in [0, 1]$. This measure is appropriate when we are interested in the extent to which the volume of trade has been restricted and is more in the spirit of the MTRI.

5. Conclusion

Measuring the total impact of trade barriers for a whole economy or even a single sector through an index that would be comparable across countries and time is a formidable project. Nevertheless, given the importance of the subject, measures of various kinds have been proposed. In order to classify the large number of indexes covered in our review, we have proposed a typology based on three categories: incidence, outcome and equivalence.

Both incidence and outcome measures have theoretical shortcomings and are pragmatic rather than theoretical measures. Incidence measures are solid in one sense: they are relatively easy to compute and depend directly and only on policy actions. For this reason, they are traditionally used for policy commitments. However, they present several weaknesses. First of all, they do not take the specific features of the economy being studied into account and, for instance, they are not able to give any indication that trade is more restricted by the increases in protection of more elastic goods. More generally, they have no theoretical ground so that they raise serious interpretation problems. The most recent contributions to the literature make it clear that incidence measures are ‘answers without questions’: they are defined by the formulae or techniques embodied in their generation but the interpretation is questionable and it is not easy to say exactly what information is conveyed.

Outcome measures do not raise inescapable problems of calculation but their theoretical consistency is also in doubt. In this case, the key issue is choosing which weights should be used. However, any fixed set of weights, either computed or estimated (as for free trade imports) would ignore elasticity effects and substitution possibilities resulting from trade protection.

Coming to the equivalence measures, although there are several different concepts of restrictiveness, they all have in common the fact that each of them defines a reference situation as a yardstick which makes it possible to determine both the relative and absolute degree of restrictiveness. The relative property allows us to compare national policies (or tariff reforms) with each other; absolute measurement allows scaling, in the sense that one can say, for example, that protection has doubled from one situation to another. They are theoretically consistent and do not raise interpretation problems but they are definitely more complex to compute. As a matter of fact, they cannot be computed by relying on observable data only and need counterfactual weights.

If we look at trade negotiations, incidence measures are clearly preferred since they do not take variables which cannot be completely controlled into account such as the weights of outcome measures or the results of the model to be used in the calculation of equivalence indexes. This is especially true for aggregation across products: it is quite difficult, indeed, to envisage the actual use of outcome or equivalent measures in order to express overall targets for tariff reduction commitments.

The situation is quite different for aggregation across policy instruments. Here, incidence indexes do not provide adequate answers if, for example, an AVE needs to be computed: the methodology recently adopted for the calculation of AVEs in the case of agricultural specific tariffs is based on a price-gap approach which is an example of outcome index. There is also a chance that an equivalent approach may be used for the calculation of the tariff-rate quota expansion that would be required in order to compensate for the ‘deviation’ from the formula cut commitments for sensitive products. The EU proposal on this issue, in fact, is similar to the approach proposed by Sharma (2006) that was presented in Section 3.3.

However, even if the theoretically sound indexes are not explicitly used to express commitments, they can provide a benchmark for evaluating more readily computable tariff indexes. In this respect, results show that the trade-weighted average tariff factor reduction could be a proxy for assessing market access improvements although in many instances it clearly underestimates the welfare impact, especially when the number of commodities considered is small and when the dispersion of tariffs is low. However, when we aggregate a large number of tariffs, or when the dispersion is large, the approximation is not very satisfactory and often leads to an underestimation of the trade restrictiveness.

If we examine the most recent contributions to the literature, it would appear that the theoretically sound approach suggested by Anderson and Neary significantly influenced the terms of the professional debate. The discussion presently focuses on the practical feasibility or how best to calculate different indicators whereas the interpretation and the properties of the indicators themselves are predetermined by their theoretical definition. In this respect, it is worth recalling that equivalence measures inherit the limitations of the assumptions as well as the defects of the model that determine the data required by the index definition. The usual assumptions underlying the definition of the trade balance function (single utility-maximizing consumer, competitive markets, exogenous world prices, etc.) are quite restrictive. It is quite obvious, indeed, that no index can be better than the model used to compute it. Empirical knowledge is lagging behind and the overall picture which emerges of the quality and reliability of the models remains somewhat bleak. Practical implementation of the theoretical indexes as proposed by the authors requires using general equilibrium models that do not allow for the degree of detail necessary to take into account the considerable tariff dispersion existing in reality. Partial equilibrium approximations of the equivalence measures included in this review have been carried out assuming simple functional forms and *ad hoc* elasticities of substitutions.

Clearly, with these drawbacks, there is no chance of providing satisfactory results in all possible cases. The different protection measures that have been reviewed do not seem to yield a coherent way to measure the degree of protection for any particular country or sector. Looking at the actual figures, there are large differences in protection measures for each country or sector. This leads us to ask whether there are any coherent patterns to these various figures. Unfortunately, the answer appears to be negative and there is no single measure which dominates all others.

On the other hand, the main advantage of a theoretically consistent indicator is to prevent any problems of interpretation, although there could be many problems in terms of practical implementation. In this respect, there may be a tendency of the casual reader to read more significance than warranted into the reported levels of the indicators. Different measures can behave in different ways and several numerical measures of the degree of protection can be useful at the same time. The use of such measures as well as whether different measures are appropriate for different circumstances thus becomes the issue. In many cases, protection indicators should be thought of as building blocks for models and evaluations not as an end in themselves. Accordingly, we cannot conclude the survey of the literature with a glowing recommendation for a single measure of protection. Trade restrictiveness is not a simple undifferentiated concept and different dimensions of trade policy require different indexes to be pinpointed.

Acknowledgements

This work was supported by the Agricultural Trade Agreements (TRADEAG) project, funded by the European Commission under contract no. FP6-513666.

Notes

1. Pritchett (1996) provides a different definition of ‘outcome-based measures’, referring to them as those assessing what the outcome would have been without the trade barriers. In our terminology, this definition includes all the measures

using a counterfactual approach, thus encompassing both outcome and equivalence measures.

2. The most widely available source of information on NTBs is the TRAINS database. It is widely used in research to generate frequency counts of the share of tariff lines or imports covered by NTBs or certain types of NTBs (Ando and Fujii, 2001).
3. Cline (2005) calculates a 'total tariff equivalent' as the average of tariffs and tariff equivalents of NTBs.
4. They analyse the impact of environment-related trade barriers and distinguish between risk and environment management, on the one hand, and protectionist policies on the other: according to their methodology, half of world trade is potentially affected by environmental protectionism.
5. This is what Ferrantino (2006) calls the 'handicraft' method.
6. Adding AVEs of NTBs and tariffs to obtain an overall level of protection in principle assumes that none of the protection instruments is binding. Alternatively, if there is any reason to believe that one of the policy instruments is binding, then it can be defined (Kee *et al.*, 2006) as $pr_{i,k} = \max(ave_{i,k} + t_{i,k})$.
7. For example, Gibson *et al.* (2001) find a tariff peak of 540% for sugar beet in the EU. From the same specific tariff, Bureau *et al.* (2000) derive 'only' a 69% *ad valorem* tariff.
8. These groups are defined on the basis of a hierarchical clustering based on GDP per capita.
9. In principle $P_M E(1 + t)$ is the full domestic price of the imported good. If it is rationed by a non-price mechanism, $1 + t$ includes the marginal value of waiting time, bribery or other costs incurred to purchase the good.
10. The methodology follows Kohli (1991) and Harrigan (1997) where imports are treated as inputs into domestic production rather than as final consumption goods as in most of the literature.
11. An example is provided by a commodity such as chocolate. Chocolate is more protected than cocoa beans or cocoa paste in the EU and the USA but this does not necessarily imply the presence of tariff escalation since the technological process also involves the introduction of sugar, which is protected by very high tariffs (Bureau *et al*., 2004).
12. See Section 3.2 for a description of the NRR.
13. When individual tariff rates are not available, some authors determine the 'collected tariff ratios'. The average rate is determined by calculating the revenue collected from tariffs and duties as a percentage of total imports (Edwards, 1998).
14. The share of the domestic value of consumption is another alternative, but also biased to the extent that high tariffs reduce consumption. Similar to production, consumption data are generally not available at the tariff line level.
15. MAcMap-HS6 database provides AVE measures of tariff duties and tariff rate quotas for 163 countries and 208 partners, at the six-digit level of the harmonized system (see Bouët *et al.*, 2004).
16. For a recent appraisal of the literature on this measure of protection see Greenaway and Miller (2003).
17. Accordingly, each derivative can be equal to the supply function or to minus the input demand function if the good is an intermediate input.
18. Anderson and Neary (2003) argue (footnote 8) that 'there is a rationale for a *ceteris paribus* trade restrictiveness index that fixes world prices even when these

prices are in fact endogenous'. Such a 'rationale' may be represented by the fact that, by keeping world price constant, we focus on the component of welfare explained by allocative inefficiency within the country, and not by the degree of market power of the country.

19. More generally, Neary (1998) shows how the failure to select a reference untaxed good leads to misleading results in the theory of trade policy.

References

Aitken, B.J. (1973) The effect of the EEC and EFTA on European trade: a temporal cross-section analysis. *American Economic Review* 63(5): 881–892.

Anderson, J. (1991) The coefficient of trade utilization: the cheese case. In R. Baldwin (ed.), *Empirical Studies of Commercial Policy*. Chicago, IL: NBER and University of Chicago Press.

Anderson, J. (1994) The theory of protection. In D. Greenaway and L.A. Winters (eds), *Surveys of International Trade*. Oxford: Basil Blackwell.

Anderson, J. (1995) Tariff-index theory. *Review of International Economics* 3(2): 156–173.

Anderson, J. (1998a) Trade restrictiveness benchmarks. *The Economic Journal* 44: 1111–1125.

Anderson, J. (1998b) Effective protection redux. *Journal of International Economics* 44: 21–44.

Anderson, K. (2002) Measuring effects of trade policy: how far have we come? CEPR Discussion Paper 3579.

Anderson, J.E. and Martin, W. (1993) The welfare analysis of fiscal policy: a simple unified account. Working Paper of the Department of Economics, Boston College.

Anderson, J. and Neary, P. (1990) The coefficient of trade utilization: back to the Baldwin envelope. In R.W. Jones and A.O. Krueger (eds), *The Political Economy of International Trade* (pp. 49–71). London: Basil Blackwell.

Anderson, J. and Neary, P. (1992) Trade reform with quotas, partial rent retention and tariffs. *Econometrica* 60(1): 57–76.

Anderson, J. and Neary, P. (1994) Measuring the restrictiveness of trade policy. *World Bank Economic Review* 8(2): 151–170.

Anderson, J. and Neary, P. (1996) A new approach to evaluating trade policy. *World Bank Economic Review* 63: 107–125.

Anderson, J. and Neary, P. (2003) The mercantilist index of trade policy. *International Economic Review* 44(2): 627–649.

Anderson, J. and Neary, P. (2005) Measuring trade policy restrictiveness: a non-technical introduction. In J. Anderson and P. Neary (eds), *Measuring the Restrictiveness of International Trade Policy*. Cambridge, MA: MIT Press.

Anderson, J. and Neary, P. (2007) Welfare vs. market access: the implications of tariff structure for tariff reform. *Journal of International Economics* 71(1): 187–205.

Anderson, J.E., Bannister, G.J. and Neary, P.J. (1995) Domestic distortions and international trade. *International Economic Review* 36: 139–156.

Ando, M. and Fujii, T. (2001) The costs of trade protection: estimating tariff equivalents of non-tariff measures in APEC economies. Mimeo, Keio University.

Andriamananjara, S. and Nash J. (1997) Have trade policy reforms led to greater openness in developing countries? The World Bank, Policy Research Working Paper 1730.

Andriamananjara, S., Dean, J.M., Feinberg, R., Ferrantino, M.J., Ludema, R. and Tsigas, M. (2004) The effects of non-tariff measures on prices, trade, and welfare: CGE implementation of policy-based price comparisons. Paper prepared for the APEC

Capacity-Building Workshop on Quantitative Methods for Assessing NTMs and Trade Facilitation, Bangkok, Thailand.

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, DC.

Antimiani, A. and Salvatici, L. (2005) EU trade policies: benchmarking protection in a general equilibrium framework. Paper presented at the ETSG 2005 Dublin, 7th Annual Conference, University College Dublin.

Antimiani, A., Conforti, P. and Salvatici, L. (2003) The effective rate of protection of European agrifood sector. Working Paper Osservatorio sulle politicheagricole dellUE 20, INEA, Rome.

Bacchetta, M. and Bora, B. (2001) Post-Uruguay Round market access barriers for industrial products. UNCTAD Study Series on Policy Issues in International Trade and Commodities 12.

Bach, M. and Martin, W. (2001) Would the right tariff aggregator please stand up? *Journal of Policy Modeling* 23(6): 621–635.

Balassa, B. (1965) Tariff protection in industrial countries: an evaluation. *Journal of Political Economy* 73: 573–594.

Balassa, B. (1985) Exports, policy choices and economic growth in developing countries after the 1973 oil shock. *Journal of Development Economics* 18: 23–35.

Baldwin, R. (1989) Measuring nontariff trade policies. NBER Working Paper 2978.

Baldwin, R. (2003) Openness and growth: what's the empirical relationship? NBER Working Paper 9578.

Barro, R.J. and Lee, J.-W. (1994) Data set for a panel of 138 countries. Harvard, MA.

Beghin, J.C. and Bureau, J.C. (2001) Quantitative policy analysis of sanitary, phytosanitary and technical barriers to trade. *Économie Internationale* 87: 107–130.

Bhagwati, J. (1965) On the equivalence of tariffs and quotas. In R.E. Caves, H.G. Johnson and P.B. Kenen (eds.), *Trade Growth and the Balance of Payments*. Chicago, IL: Rand-McNally.

Bhagwati, J. (1978) *Foreign Trade Regimes and Economic Development: Anatomy and Consequences of Exchange Control Regimes*. New York: NBER.

Bhagwati, J.N. and Srinivasan, T.N. (1984) *Lectures on International Trade*. Cambridge, MA: MIT Press.

Bora, B., Kuwahara, A. and Laird, S. (2002) Quantification of non-tariff measures. Policy Issues in International Trade and Commodities Study Series 18.

Bouët, A., Decreux, Y., Fontagné, L., Jean, S. and Laborde, D. (2004) A consistent *ad valorem* equivalent measure of protection across the world. The MacMAP–HS6 database. CEPII Working Paper 2004–22.

Bradford, S. (2003) Paying the price: final goods protection in OECD countries. *Review of Economics and Statistics* 85(1): 24–37.

Bruno, M. (1979) Protection and tariff change under general equilibrium. *International Economic Review* 3: 205–226.

Bureau, J.-C. and Kalaitzandonakes, N. (1995) Measuring effective protection as a superlative index number. *American Journal of Agricultural Economics* 77: 279–290.

Bureau, J.-C. and Salvatici, L. (2004a) WTO negotiations on market access in agriculture: a comparison of alternative tariff cut proposals for the EU and the US. *Topics in Economic Analysis and Policy* 4(1): Article 8, available at http://www.bepress.com/bejeap/topics/vol4/iss1/art8.

Bureau, J.-C. and Salvatici, L. (2004b) WTO negotiations on market access: what we know, what we don't and what we should in agricultural policy reform and the WTO: where are we heading? In G. Anania, M.E. Bohman, C.A. Carter and A.F. McCalla (eds). Northampton, MA: Edward Elgar.

Bureau, J.-C. and Salvatici, L. (2005) Agricultural trade restrictiveness in the European Union and the United States. *Agricultural Economics* 33: 479–490.

Bureau, J.-C., Fulponi, L. and Salvatici, L. (2000) Comparing EU and US trade liberalisation under the Uruguay Round agreement on agriculture. *European Review of Agricultural Economics* 27(3): 1–22.

Bureau, J.-C., Bernard, F., Gallezot, J. and Gozlan, E. (2004) The measurement of protection on the value added of processed food products in the EU, the US, Japan and South Africa. A Preliminary Assessment of its Impact on Exports of African Products, Final Report, The World Bank, Washington, DC.

Cadot, O., Carrere, C., de Melo, J. and Tumurchudur, B. (2005) Product specific rules of origin in EU and US preferential trading agreements: an assessment. CEPR Discussion Paper 4998.

Calvin, L. and Krissoff, B. (1998) Technical barriers to trade: a case study of phytosanitary barriers and US–Japanese apple trade. *Journal of Agricultural and Resource Economics* 23(2): 351–356.

Chau, N.H., Färe, R. and Grosskoff, S. (2003) Trade restrictiveness and efficiency. *International Economic Review* 44(3): 1079–1095.

Chen, B.L. (1999) Trade openness and economic growth: evidence in East Asia and Latin America. *Journal of Economic Integration* 14(2): 265–295.

Cline, W.R. (2002) An index of industrial country trade policy toward developing countries. Center for Global Development Working Paper 14.

Cline, W.R. (2005) Enhancing the IMF's index of trade restrictiveness. IMF Working Paper, quoted by IMF.

Corden, M. (1966) The effective protective rate, the uniform tariff equivalent and the average tariff. *Economic Record* 200–216.

Dean, J.M., Feinberg, R. and Ferrantino, M.(2003) Estimating the tariff-equivalent of NTMs. Office of Economics Working Paper 2003-12-B, US International Trade Commission.

Deardorff, A.V. and Stern, R.M. (1997) Measurement of non-tariff barriers, OECD Economics Department Working Paper 179 (OCDE/GD(97)/129). Paris: Organization for Economic Cooperation and Development.

Deardorff, A.V. and Stern, M.R. (1998) *Measurement of Nontariff Barriers*. Ann Arbor, MI: University of Michigan Press.

Deaton, A. (1979) The distance function in consumer behaviour with applications to index numbers and optimal taxation. *Review of Economic Studies* 46(3): 391–405.

Debreu, G. (1951) The coefficient of resource utilization. *Econometrica*, 19: 273–292.

Dee, P. and Ferrantino, M. (2005) *Quantitative Methods for Assessing the Effects of Non-tariff Measures and Trade Facilitation* (Introductory chapter, pp. 13–41). Singapore: APEC Secretariat and World Scientific.

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

Dollar, D. (1992) Outward-oriented developing economies really do grow more rapidly: evidence from 95 LDCs, 1976–1985. *Economic Development and Cultural Change* 40: 523–544.

Dollar, D. and Kraay, A. (2004) Trade, growth, and poverty. *The Economic Journal* 114: F22–F49.

Donnelly, W.A. and Manifold, D. (2005) A compilation of reported non-tariff measures: description of the information. Office of Economics Working Paper 2005-05-A, US International Trade Commission.

Edwards, S. (1993) Openness, trade liberalization and growth in developing countries. *Journal of Economic Literature*, XXXI: 1358–1393.

Edwards, S. (1998) Openness, productivity and growth: what do we really know? *The Economic Journal* 108: 383–398.

Estevadeordal, A. (2000) Negotiating preferential access: the case of the North American Free Trade Agreement. *Journal of World Trade* 34(1): 141–166.
Feenstra, R.C. (1995) Estimating the effects of trade policy. In G. Grossman and K. Rogoff (eds), *Handbook of International Economics*, Vol. III. Amsterdam: Elsevier.
Feenstra, R.C. and Boorstein, R. (1991) Quality upgrading and its welfare cost in U.S. steel imports, 1969–74. *International Trade and Trade Policy* (pp. 167–186). Cambridge, MA: MIT Press.
Ferrantino, M.J. (2006) Quantifying the trade and economic effects of non-tariff measures. OECD Trade Policy Working Paper 28.
Fontagné, L., von Kirchbach, F. and Mimouni, M. (2001) A first assessment of environmental-related trade barriers. CEPII Working Paper 2001/01.
Frankel, J.A. and Romer, D. (1999) Does trade cause growth? *American Economic Review* 89(3): 379–399.
Gehlhar, M. and Wainio, J. (2002) A reevaluation of processed food tariffs facing exporters: implications for liberalization. Paper presented at the 5th Annual Conference on Global Economic Analysis, Taipei, Taiwan.
Gibson, P., Wainio, J., Whitley, D. and Bohman, M. (2001) Profiles of tariffs in global agricultural markets. USDA Agricultural Economic Report 796, US Department of Agriculture, Economic Research Service, Washington, DC.
Greenaway, D. and Milner, C.R. (2003) Effective protection, policy appraisal and trade policy reform. *World Economy* 26(4): 441–456.
Harrigan, J. (1997) Technology, factor supplies, and international specialization: estimating the neoclassical model. *American Economic Review* 87(4): 475–494.
Harrison, A., (1996) Openness and growth: a time-series, cross-country analysis for developing countries. *Journal of Development Economics* 48: 419–447.
Heitger, B. (1987) Import protection and export performance – their impact on economic growth. *Weltwirtschaftliches Archiv* 123(2): 249–261.
IMF (2005) Enhancing the IMF's index of trade restrictiveness. IMF Working Paper.
Jank, M.S., Fuchsloch, I. and Kutas, G. (2002) Agricultural liberalization in multilateral and regional trade negotiations. Inter American Development Bank, Washington, DC.
Kee, H.-L., Nicita, A. and Olarreaga, M. (2004a) Import demand elasticities and trade distortions. CEPR Working Paper 4669, London.
Kee, H.-L., Nicita, A. and Olarreaga, M. (2004b) Ad-valorem equivalents of non-tariff barriers. Mimeo, The World Bank.
Kee, H.-L., Nicita, A. and Olarreaga, M. (2006) Estimating trade restrictiveness indices. Policy Research Working Paper 3840, The World Bank.
Kohli, U. (1991) *Technology, Duality and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports*. Ann Arbor, MI: University of Michigan Press.
Krueger, A.O. (1978) *Liberalization Attempts and Consequences*. Cambridge, MA: Ballinger.
Laird, S. and Yeats, A. (1990) *Quantitative Methods for Trade-Barrier Analysis*. New York: Macmillan.
Leamer, E. (1988) Measures of openness. In R. Baldwin (ed.), *Trade Policy issues and Empirical Analysis* (pp. 147–200). Chicago, IL: University of Chicago Press.
Leamer, E. (1990) Latin America as a target of trade barriers erected by the major developed countries in 1983. *Journal of Development Economics* 32: 337–368.
Leith, J.C. (1968) Substitution and supply elasticities in calculating the effective protection rate. *Quarterly Journal of Economics* 82(4): 588–601.
Lindland, J. (1997) The impact of the Uruguay Round on tariff escalation in agricultural products. *Food Policy* 22(6): 487–500.
Linkins, L.A. and Arce, H.M. (1994) Estimating tariff equivalents of nontariff barriers. Office of Economics Working Paper 94-06-A(r), US International Trade Commission.

Lloyd, P.J. (1975) Substitution effects and biases in non-true price indices. *American Economic Review* 65(3): 301–313.

Lloyd, P.J. and MacLaren, D. (2002) Measures of trade openness using CGE analysis. *Journal of Policy Modeling* 24: 67–81.

Manole, V. and Martin, W. (2005) Keeping the devil in the details: a feasible approach to aggregating trade distortions. Paper presented at the VII ETSG Conference. Dublin, 7–9 September.

Nash, J. (1993) Trade policy reform implementation in Sub-Saharan Africa: how much heat and how much light? The World Bank Policy Research Working Paper 1218, Washington, DC.

Neary, J.P. (1998) Pitfalls in the theory of international trade policy : concertina reforms of tariffs and subsidies to high-technology. *Scandinavian Journal of Economics* 100(1): 187–206.

Nogues, J., Olechowski, A. and Winters, L.A. (1986) The extent of nontariff barriers to industrial countries' imports. *World Bank Economic Review* 1: 181–199.

OECD (1994) *Barriers to Trade with the Economies in Transition*. Paris: OECD.

O'Rourke, K.H. (1997) Measuring protection: a cautionary tale. *Journal of Development Economics* 53: 169–183.

Piermartini, R. and The, R. (2005) Demystifying modelling methods for trade policy. Discussion Paper 10. Economic Research and Statistics Division, World Trade Organization, Geneva.

Pritchett, L. (1996) Measuring outward orientation in LDCs: can it be done? *Journal of Development Economics* 49(2): 307–335.

Pritchett, L. and Sethi, G. (1994) Tariff rates, tariff revenue, and tariff reform: some new facts. *World Bank Economic Review* 8(1): 1–16.

Rodrìguez, F. and Rodrik, D. (1999) Trade policy and economic growth: a skeptic's guide to the cross-national evidence. NBER Working Paper 7081.

Sachs, J.D. and Warner, A.M. (1995) Economic reform and the process of economic integration. *Brookings Papers of Economic Activity* 95(1): 1–118.

Salvatici, L. (2001) Trade distortion indexes and multi-regional AGE models: the case of the common agricultural policy. Working paper of the Dipartimento di Economia Pubblica 45, Università degli Studi di Roma 'La Sapienza'.

Sandrey, R. (2000) The relative tariff ratio index. New Zealand Trade Consortium Working Paper 7, New Zealand Trade Consortium with the New Zealand Institute of Economic Research.

Sharma, R. (2006) On the equivalence of tariffs and quotas for sensitive products in the WTO agricultural negotiations. Commodities and Trade Division, Rome: FAO.

UNCTAD (2005) Methodologies, classifications, quantification and development impacts of non-tariff barriers. Commission on Trade in Goods and Services, and Commodities. Note by the UNCTAD secretariat, TD/B/COM.1/EM.27/2.

Woodland, A.D. (1982) *International Trade and Resource Allocation*. Amsterdam: North Holland.

World Bank (1987) *World Development Report 1987*. New York: Oxford University Press.

Yanikkaya, H. (2003) Trade openness and economic growth: a cross-country empirical investigation. *Journal of Development Economics* 72: 57–89.

Yue, C., Beghin, J.C. and Jensen, H.H. (2006) Tariff equivalent of technical barriers to trade with imperfect substitution and trade costs. *American Journal of Agricultural Economics* 88(4): 947–960.