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**TRADE DISTORTION INDEXES AND MULTI-
REGIONAL AGE MODELS: THE CASE OF THE
COMMON AGRICULTURAL POLICY**

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Abstract

In this paper, we build on the insights of the Trade Restrictiveness Index (TRI) approach by computing uniform tariff equivalents for the European Union primary sector using the Global Trade Analysis Project model and its associated data base. The main contribution of the paper is to extend and adapt the definition of the TRI, in order to make it consistent with the structure of a multi-regional Applied General Equilibrium model. In this perspective, we define a “modified TRI” based on the direct welfare evaluation (rather than on the Balance of trade function) and extend its definition in order to take into account the terms of trade impact. Finally, an empirical application of the index is provided with reference to two policy scenarios: the liberalization of the Common Agricultural Policy and the implementation of the “Agenda 2000” reform.

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TRADE DISTORTION INDEXES AND MULTI-REGIONAL AGE MODELS: THE CASE OF THE COMMON AGRICULTURAL POLICY

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1. Introduction

The paper studies the impact of the Common Agricultural Policy (CAP) reform focusing on the move from market support to direct payments. Since the impact of alternative systems of direct payments on agricultural trade crucially depends on production technologies and the extent of factor mobility between sectors, we decided to use a global Applied General Equilibrium (AGE) model such as Global Trade Analysis Project (GTAP) one. We simulated two policy experiments: the “decoupled” scenario, referring to the reforms implemented in the ‘90s (“MacSharry Reform” in 1992 and “Agenda 2000” in 1999); the “free trade” scenario, involving a (almost) complete liberalization of the European Union (EU) primary sector. In order to provide a more detailed representation of the policy mechanisms involved, a number of modifications have been made to the standard model, drawing upon a

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growing number of GTAP applications that focus on the CAP (Veenendaal et al., 2000).

We draw on two main strands of literature. The first one refers to the application of applied general equilibrium analysis for agriculture (Hertel, 1999). The second one refers to the use of index numbers for policy analysis and, more specifically, to the definition of theoretically consistent indexes for the measurement of protection (Salvatici, 2000).

As far as the latter is concerned, one of the most interesting suggestions in the literature is the Trade Restrictiveness Index (TRI), proposed by Anderson and Neary, (1994, 1996). The TRI can be used to track the welfare costs of changes in a large number of distortions. We adapt and extend the TRI definition in order to make it consistent with the structure of the GTAP model (Hertel, 1997). In order to be able to do that, we modify the standard model, introducing a new policy variable – the “uniform tariff equivalent”. Furthermore, we needed to recast the definition of the TRI in order to make it consistent with the GTAP both in terms of modeling assumptions (i.e., the terms of trade impact) and in terms of methodological choices (i.e., the approach adopted for the measurement of welfare).

We compute uniform tariff equivalents in terms of welfare for the Common Agricultural Policy (CAP) of the European Union (EU) agriculture and food processing sectors using the GTAP model. Two policy experiments are implemented, drawing upon a growing number of GTAP applications that focus on the CAP: the “decoupled” scenario, referring to the reforms implemented in the ‘90s (“MacSharry Reform” in 1992 and

“Agenda 2000” in 1999); the “free trade” scenario, involving a (almost) complete liberalization of the EU primary sector.

The outline of the paper is as follows. Section 2 details the specification of the model. Section 3 defines a TRI based on the direct welfare evaluation rather than on the Balance of trade function, and extends its definition in order to take into account the terms of trade impact. Section 4 presents the empirical implementation of two policy scenarios: the liberalization of the CAP and the decoupling of support implied by the two main reforms of the ‘90s, namely the MacSharry Reform and Agenda 2000. Section 5 concludes.

2. Model specification

The standard GTAP model assumes constant returns to scale technology, perfectly competitive markets and a non-homothetic private demand system, where foreign trade is described according to an Armington specification. There is one household in each region which receives the factor rewards and consumes both domestic and imported goods (Hertel, 1997).

The analysis is comparative static, with the benchmark equilibrium (in our case, pre-CAP reform) subjected to a ‘policy shock’ and a new ‘counterfactual’ equilibrium computed. All equations are in percentage change form, and after determining a new equilibrium state the changes in all endogenous variables are also expressed in percentage changes. Changes in aggregate prices are calculated as weighted average price indexes using individual commodities shares as weights. All values terms are expressed in

US\$ (referred to the base year of the data base) and the model is solved using the GEMPACK software package (Harrison and Pearson, 1994).

The GTAP project has developed a comprehensive data base using information from numerous international sources. We adopt the GTAP version 4 data base that uses 1995 data (McDougall, 1998). One of the main features of this version of the data base is the detailed sectoral classification of agricultural and food products. It distinguishes twelve sectors within agriculture, and eight within the area of food, beverages, and tobacco. However, since the PC version of the model cannot handle more than ten sectors, as a consequence of the focus on CAP reform in our specification there are seven primary agricultural sectors (wheat; cereal grains; vegetables, fruit, nuts; oil seeds; raw milk, other crops, livestock), and one processed food sector (agribusiness products). The rest of the economy is represented with two sectors (other commodities, natural resources). There are 3 regions: given the focus of the analysis, one of them is EUR (the 15 EU members after the 1995 enlargement), while within the rest of the world (WOR) a major player like the USA has been singled out.

The agricultural policy measures which have been incorporated into the data base for the OECD member countries are based on producer subsidy equivalent (PSE) calculations done at the OECD for the year 1995. As far as border measures are concerned, they are determined according to the market price support component of the PSE. In the case of importable, the ad-valorem tariff equivalent (to all the existing border measures) is expressed as a percentage difference between the domestic market price and the world price. The same type of price comparison is carried over to the

export side as well. In the same vein, the total gross PSE less the market support component determines the producer subsidy (McDougall, 1998).

Table 1 shows supply and export subsidies, and import tariffs in our data referring to the EU. It should be noted that price comparisons (between domestic and world prices) are trade-weighted in aggregating up to 10 sector. The fact that trade flows for the same sector could be made up of different products (or of the same products with different relative weights) explains the difference between the rates applied to different regions and between the import levies and the export subsidies for the same sector. For example, if the heavily protected commodities are not important exports, then the export subsidy will tend to be below the import tariff.

The data confirm the existence of a very uneven structure of protection for the EU agriculture. On the one hand there are sectors without any form of protection, either because there are not international trade flows (as in the case of raw milk) or because international commitments do not allow for protection (as in the case of oilseeds). On the other hand, cereals and livestock are the most protected sectors.

Domestic subsidies are generally higher for crops (cereals and oilseeds). This is not surprising, since in these sectors significant direct payments were introduced with the MacSharry Reform of 1992. However, it raises some doubts the fact that the compensatory payments are modelled as producer subsidies, since such a choice does not recognize at all the (partial) decoupling that has been introduced with the Reform. We'll deal with this issue in Section 4.2.

3. Tariff equivalents in GTAP

3.1 Terms of trade

The TRI (Δ) is defined by Anderson and Neary (1994; 1996) 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 at a given level of utility. The focus of the index is on economic efficiency, defined in terms of the welfare of a representative agent. Distributive issues are ignored and tariffs are assumed to be set exogenously by the government, who redistributes tariff revenues to the representative agent. Assuming a small economy under perfect competition and constant returns to scale, only the dead-weight losses from distorting production and consumption decisions are considered, while possible gains from improving the terms of trade, or from shifting profits between countries due to changes in the scale of firms are ignored. Formally,

$$(1) \quad \Delta(\pi^1, u^0, z) \equiv [\Delta : B(\pi^1 / \Delta, u^0, z) = 0] .$$

where $B(.)$ is the Balance of trade function. Such a function is equal to the net income transfer (equal to zero in equilibrium) required to reach a given level of aggregate national welfare (u) for an economy with a given vector of domestic prices (π) and a vector (k) which includes all the variables assumed exogenous (world prices, factor endowments, etc.). The Balance of trade function represents the external budget constraint of the economy, since it summarizes the three possible sources of funds for financing import: earnings from exports, earnings from trade distortions or international transfers.

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 its period 0 level. Finally, since Δ deflates period 1 prices and quantities to attain period 0 utility, it is a compensating variation type of measure.

Apparently, the small country assumption adopted in the definition of the TRI rules out any possible terms of trade effect. On the contrary, in the GTAP model terms of trade play a crucial role.

First of all, since it is a multi-regional model, by its very nature GTAP aims to assess the impact of individual countries' decisions on other countries, international trade and worldwide welfare. If products from various regions were assumed to be identical, any country would be only a fraction of the world market, so that it could still be the case that terms of trade are not significant (though this would be difficult to argue for large players such as the EU). However, once one introduces the idea of product differentiation, tariffs will result in terms of trade changes regardless of the countries' sizes.

The traditional approach to modelling product differentiation, due to Armington (1969), is to assume that it has to do with exogenous considerations that somehow are linked to the country of origin. This is the assumption adopted in the standard GTAP model, where the Armington aggregation is specific to each agent within the region. Under this approach, the composite good C_i is assumed to be an aggregation of domestically-

produced quantities of product i , D_i , and imported quantities, M_{ir} (imports of i sourced from region r)

$$(2) \quad C_i = g[D_i, h(M_{ir}, M_{is}, \dots)]$$

where both the function g and the function h are CES functions.

Largely based on results of sensitivity analyses of models to changes in the substitution elasticities in CES-based Armington functions, modellers have come to appreciate the extent to which these parameters determine terms of trade effects. The Armington assumption, as a matter of fact, implies that each importer, however small the region may be, has some degree of market power, and is therefore able to influence world prices. The terms of trade effects will be larger, the larger the elasticity of substitution between domestic and combined foreign goods, because the import demand equation becomes flatter, which in turn implies larger quantity and therefore price effects on world markets.

In order to apply the “TRI approach” within the GTAP model, then, we need to re-define the uniform tariff equivalent relaxing the small country assumption. The vector of domestic prices π is a function of the tariff factors vector T . To accommodate this, the definition of the TRI [see equation (1)] is modified as follows

$$(3) \quad \Delta^W [\pi(T^1), u^0, k^0] = \{\Delta^W : B[\pi(T^1)/\Delta^W, u^0, k^0] = 0\},$$

where (Δ^W) is the TRI with endogenous world prices.

In the case of the TRI, totally differentiating equation (1), we get

$$(4) \quad \frac{B_\pi'}{\Delta} d\pi - \frac{B_\pi' \pi}{\Delta^2} d\Delta = 0$$

Using the small country assumption ($dT = d\pi$), the proportional change in the TRI is a weighted average of the proportional changes in domestic prices

$$(5) \quad \hat{\Delta} = \sum_i \left(\frac{B_{\pi_i} \pi_i}{B_{\pi} \pi} \right) \hat{\pi}_i.$$

With endogenous world prices ($dT = d\pi - d\pi^*$), totally differentiating equation (3) we get

$$(6) \quad \frac{B_{\pi} \pi_T}{\Delta^w} dT - \frac{B_{\pi} \pi_T T}{(\Delta^w)^2} d\Delta^w = 0,$$

then

$$(7) \quad \hat{\Delta}^w = \sum_i \left(\frac{B_{\pi_i} \pi_{T_i} T_i}{B_{\pi} \pi_T T} \right) \hat{\pi}_i.$$

As in the case of equation (5), the weights in equation (7) can be interpreted as the proportions of marginal deadweight loss due to each tariff. That is, the partial derivatives of the Balance of trade function with respect to tariff factors provide the vector of transfers needed to compensate for changes in tariffs. However, the structure of these derivatives is quite different ($B_T' = B_{\pi} \pi_T$) with endogenous world prices.

The difference in the derivatives of the Balance of trade function makes clear why the small country assumption is important in order to have a *well-behaved* uniform tariff equivalent function. Counterintuitive “second best” results, as a matter of fact, can be ruled only if we deal with an *efficient protection*, that is if it is not possible to get an higher welfare through tariff increases (formally, this implies $\partial B / \partial T_i > 0$). For a small

country this is the normal case, although there is always the possibility of unusually large cross price effects. However, if we allow the importer to benefit from a reduction of the world price, it will be much easier to obtain welfare improvements through tariff increases.

3.2 *Direct welfare evaluation*

The theoretical framework used for the definition of the TRI –i.e., the Balance of trade function– implies that the welfare (compensating or equivalent) variations considered are *compensation measures*, since they evaluate the surplus foreign exchange which should be extracted from (or must given to) the economy when the economic policy is switched from its initial level to its new level or back again while simultaneously maintaining the utility at the reference (initial or final) level. Formally, the compensating variation compensation measure (CV^c) is defined as

$$(8) \quad CV^c = B(\pi^0, u^0) - B(\pi^1, u^0) = -B(\pi^1, u^0),$$

while the equivalent variation compensation measure (EV^c) is defined as

$$(9) \quad EV^c = B(\pi^0, u^1) - B(\pi^1, u^1) = B(\pi^0, u^1),$$

where the second equalities follow from the equilibrium condition [$B(.) = 0$].

On the other hand, for numerical general equilibrium models – such as GTAP–, the most common approach to welfare evaluation involves the direct evaluation of changes in a money metric of welfare change: *Money metric of utility* measures convert the change in equilibrium utility to a change in expenditure using the representative agent's expenditure function, with the reference point being either old or new prices. (Anderson and Martin, 1993, pag.1). For open economies the class of money metric

measures is based on the Trade expenditure function $E(\pi, u)$, obtained as the difference between the consumer's Expenditure function and the Gross Domestic Product function. Accordingly, the Hicksian equivalent variation (EV^h) is defined as

$$(10) \quad EV^h = E(\pi^0, u^0) - E(\pi^0, u^1),$$

while the Hicksian compensating variation (CV^h) is defined as

$$(11) \quad CV^h = E(\pi^1, u^1) - E(\pi^1, u^0).$$

In GTAP, regional household behavior is governed by an aggregate utility function, specified over composite private consumption, composite government purchases, and savings. The model computes regional equivalent variation measures, which arise due to the simulation under consideration. The choice of EV^h as the outcome of the model is a natural one, since it allows comparison of a range of options (alternative π^1 vectors), and ensures an equal ranking of all outcomes for which the representative consumer would be indifferent (Auerbach, 1985). Since the TRI has been defined using the compensation criterion, while GTAP provides evaluations of a money metric for welfare change, it is necessary to analyse the relations between the different welfare measures.

Using the fact that the Balance of trade function is equal to

$$(12) \quad B(\pi, u) = E(\pi, u) - (\pi - \pi^*) E_\pi(\pi, u),$$

where the second term on the right hand side is net government revenue (using Shepard's Lemma), CV^c can be written as

$$(13) \quad CV^c = E(\pi^0, u^0) - (\pi^0 - \pi^*) E_\pi(\pi^0, u^0) - E(\pi^1, u^0) + (\pi^1 - \pi^*) E_\pi(\pi^1, u^0).$$

Noting that

$$(14) \quad B(\pi^1, u^1) = 0 = B(\pi^0, u^0),$$

equation (13) can be rewritten as

$$(15) \quad \begin{aligned} CV^c &= E(\pi^1, u^1) - E(\pi^1, u^0) + (\pi^1 - \pi^*) [E_\pi(\pi^1, u^0) - E_\pi(\pi^1, u^1)] = \\ &= CV^h + (\pi^1 - \pi^*) [E_\pi(\pi^1, u^0) - E_\pi(\pi^1, u^1)] \end{aligned}$$

Similarly, we may derive

$$(16) \quad EV^c = EV^h + (\pi^0 - \pi^*) [E_\pi(\pi^0, u^0) - E_\pi(\pi^0, u^1)]^1$$

Looking at the last two equations, it appears that in the absence of distortions, money metric measures of welfare change are identical to the corresponding compensation measures. However, in the presence of distortions, the equivalence between the money metric measures and the compensation measures breaks down (Anderson and Martin, 1993). The crucial economic distinction between the compensation and the money metric measures lies in the fact that the former indicate a surplus which could actually be extracted, while the latter have no such interpretation. While compensation is typically only hypothetical, its effects on consumption levels and hence on tariff revenues are included along with changes in actual revenues: this measure, then, corresponds to the Diamond-McFadden deadweight loss measure (Cornes, 1992).

Although it is quite natural to characterize the Diamond and McFadden (1974) measure as a compensating variation, it has been pointed

¹ It is worth noting that EV^c is not only a compensation measure, but it also has the attractive property of being a money metric of utility, because the magnitude of his measure

out that it is not the only, and perhaps not the most natural, measure of the compensating variation. (Cornes, 1992, p.232). The idea is that the actual revenue raised by the taxation system, rather than a hypothetical measure of compensated revenue, should be used in evaluating welfare costs of taxation. In the taxation literature, then, modified compensation measures have been suggested (Ballard, 1990; Mayshar, 1990), where the utility level is exogenously fixed in the trade expenditure function, but not in the tax revenue term.

This is very important for our purposes, since Martin (1997) shows that the money metric measures of welfare change turn out to be identical to the modified compensation measures. The modified Balance of trade function $H(\pi, u)$ which results when the hypothetical tariff revenues are replaced by the actual revenues is defined as

$$(17) \quad H(\pi, u) = E(\pi, u) - (\pi - \pi^*) E_\pi(\pi, h),$$

where h is determined by

$$(18) \quad h = \{u : B(\pi, u) = 0\},$$

and not set at the exogenous value (u).

The compensating variation modified compensation measure (CV^m) of the welfare effect of a tariff change can then be written as

$$(19) \quad \begin{aligned} CV^m &= H(\pi^0, u^0) - H(\pi^1, u^0) = \\ &= E(\pi^0, u^0) - (\pi^0 - \pi^*) E_\pi(\pi^0, u^0) - E(\pi^1, u^0) + (\pi^1 - \pi^*) E_\pi(\pi^1, u^1). \end{aligned}$$

Taking advantage of the fact that

correctly ranks alternative tariff structures according to their implied utility levels (Cornes, 1992).

$$(20) \quad E(\pi^i, u^i) - (\pi^i - \pi^*) E_{\pi}(\pi^i, u^i) = 0, \text{ for } i = 0, 1;$$

equation (19) may be rewritten as

$$(21) \quad CV^m = E(\pi^1, u^1) - E(\pi^1, u^0) = CV^h,$$

that is the money metric measure based on new prices defined in equation (11). In the same vein, it can be shown that

$$(22) \quad EV^m = E(\pi^0, u^0) - E(\pi^0, u^1) = EV^h.$$

Armed with these results, we are ready to define the uniform tariff equivalent in terms of welfare that we are going to use with the GTAP model. Since the model measures welfare using the equivalent variation (EV^h), the first step is to define an equivalent variation TRI (Δ^{EV}),

$$(23) \quad \Delta^{EV}(\pi^0, u^1, k^0) = \{\Delta^{EV} : B(\pi^0 \Delta^{EV}, u^1, k^0) = 0\},$$

which would operate on period 0 prices in order to attain period 1 utility.

The equivalent variation TRI is in principle superior because of its transitivity property (due to the fact that it is based on EV^C , which is a money metric measure of welfare), but since actual prices are not necessarily equal to a radial expansion of the free trade price vector, it will not generally be defined in the move all the way to free trade. However, by the same token, it should be noticed that the “compensating variation TRI (Δ) is not generally defined if we start from a situation of free trade. In this case, a radial contraction of distorted prices is not necessarily equal to the free trade prices.

Having defined an equivalent variation index, the next step is to express it using a direct welfare evaluation rather than a compensation one. In order to do this, we take advantage of the correspondence between the

modified Balance of trade function approach and the money metric measures of welfare. Accordingly, we define an *hicksian TRI* (Δ^h) as

$$(24) \Delta^h(\pi^0, u^1, k^0) = \{\Delta^h : H(\pi^0 \Delta^h, u^1, k^0) = 0\}.$$

The final step involves the abandoning of the small country assumption (see previous section). Using the results obtained for the TRI with endogenous prices, we define an *hicksian TRI with endogenous world prices* (Δ^{hW}) as follows

$$(25) \Delta^{hW}[\pi(T^0), u^1, k^0] = \{\Delta^{hW} : H[\pi(T^0) \Delta^{hW}, u^1, k^0] = 0\}.$$

This is the index that we are going to use in order to evaluate the impact of the policy experiments.

4. Policy experiments

In the following, we will consider two policy scenarios: firstly, a “liberalization” scenario assuming the abolition of the CAP (section 4.1); secondly, a “decoupling” scenario, where we introduce the reforms that have been implemented in the ‘90s, namely the MacSharry Reform and the Agenda 2000 (section 4.2).

4.1 CAP liberalization

Starting from the database, the shocks required to remove the agricultural domestic and trade policy instruments are summarized in Table 2. As it can be expected, the sign of the shocks indicate that in most cases we need to remove output and export subsidies, and import taxes. The only exceptions are represented by the agribusiness and vegetables sectors, where we find domestic taxes and export taxes (see Table 1). Since the interpretation of the uniform tariff equivalent would not be consistent if we

included these types of measures,² we do not consider the vegetables sector and the agribusiness production taxes in the liberalisation experiment.

Furthermore, we must take into account that in 1995 the average set-aside rate in the European Union was around 14 percent, which on average meant that for every hectare only 0.86 hectare was productive (Bach and Frandsen, 1998). Since the liberalization scenario implies the abolishment of the set-aside, we increased the productivity of the land used in the arable crops sectors by 14%.

The effects of this reform in terms of EU output are summarized in Table 3. As it could have been expected, we register a dramatic and generalized reduction of the output of the EU agricultural sector. Obviously, the largest percentage reductions occur in those sectors that were the most protected: namely, oilseeds, cereals and livestock.

On the other hand, we register an overall increase in welfare in each of the three regions. In this respect, the EU reaps the largest benefit (5369 million 1995 US\$), as a result of a huge increase in the allocative efficiency (16150 million 1995 US\$) and a significant loss resulting from the terms of trade impact (-11079 million 1995 US\$). Interestingly, the most important contribution to the efficiency gains come from the agribusiness products, followed by cereal, livestock and oilseeds.

Armed with this result, we are able to implement the counterfactual scenario leading to the computation of the relative rate of change in $\Delta^h W$. In other terms, we use the data base domestic market prices and we compute the

² Since trade liberalization could imply domestic prices lower (in the case of export subsidies) or higher (in the case of export taxes) than world prices, the sign of the change in

percentage rate of change in Δ^{hW} that would allow the same welfare gain of the CAP liberalization scenario.

It appears that the abolition of the CAP is equivalent to an 8.6 percent reduction of our index. By definition

$$(26) \quad -8.6 \cong 100 \frac{\Delta_f^{hW} - \Delta_i^{hW}}{\Delta_i^{hW}} \cong 100 \frac{0.91 - 1}{1} ,$$

where f and i denote the final and initial value of the index, respectively. Accordingly, 0.91 should be interpreted as the scalar factor of proportionality by which the initial prices would have to be adjusted if we want to ensure the same welfare gain obtained by abolishing the CAP, as it is represented in the 1995 data base. Notice that even if we deal with a complete liberalization scenario, we are not able to compute the level of the uniform tariff equivalent of the CAP ($t = 1/\Delta^{hW} - 1$). The tariffs under the counterfactual scenario, as a matter of fact, are not equal to zero, as it should be clear by the fact that most of the initial protection levels are much higher than 10%.

Actually, only the fact that the counterfactual scenario does not coincide with the free trade one allows the computation of an *equivalent variation index*, since we already mentioned that actual prices are not necessarily equal to a radial expansion of the free trade price vector. Although the new price vector does not coincide with the free trade one, it is the existence of a terms of trade impact that makes it possible to achieve the same overall welfare impact resulting from the abolition of the CAP, even

the restrictiveness index could be either negative or positive (see Salvatici, Carter and Sumner, 1999).

falling short of a full liberalization. Our counterfactual scenario, as a matter of fact, presents a lower gain in terms of allocative efficiency (7002 million 1995 US\$), but also a lower loss from the terms of trade (-1630 million 1995 US\$).

4.2 CAP decoupling

As it was mentioned in Section 2, the modelling of the CAP in the Version 4 GTAP data base is not entirely satisfactory. Following the 1992 MacSharry Reform, the share of market support in total transfers to the agricultural sector has decreased, while direct payments have increased. In the data base, these direct payments are represented as output subsidies. However, the so called “compensatory payments” are (at least partially) *decoupled*, and this implies that it is not appropriate to link them directly to production. Consequently, as far as arable crops are concerned we follow a procedure that is quite standard in the GTAP literature (Lotze and Herok, 1997; Bach and Frandsen, 1998; Frandsen et al., 1998; Jensen et al., 1998): output subsidies are adjusted and input subsidies are added to represent compensatory payments.

Since the GTAP model works in percentage changes, any policy measure has to be translated into relative terms. The level of the land subsidy in the database is determined by taking the amount of all compensation payments and direct subsidies for the cereals and oilseeds sectors in 1995 (13.5 billion of ECU) and dividing it by the total value of agricultural land as shown in the database for the EU (23.1 billion of \$). Thus we derive a subsidy level at about 75% of the factor price for land, which is similar to the figure obtained by Herok and Lotze.

After 1995, the most relevant CAP reform took place in March 1999 and it is based on the Commission's proposals put forward in the context of Agenda 2000 (EU Commission, 1997). In summary, the reform includes a reduction in cereals intervention prices (7.5% in 2000 and a further 7.5% in 2001); oilseed aid per hectare is to be aligned to that of cereals in 2002; the basic price of beef is fixed at euro 2224/t, i.e. a 20% reduction. Farmers' incomes are supported through a series of direct payments such as: cereals and oilseeds: euro 63/t, i.e. +22%; beef: increased headage payments (beef cows +48%).

The relationship between institutional prices and market prices is a matter of empirical estimation. Different scenarios can be envisaged, based on how the cut in institutional prices (-15% for cereals, -20% for beef) is fully or partially reflected in market prices. We decided to model the price component of Agenda 2000 looking at the final outcome in terms of protection. According to the EU Commission (1998), the ratio of internal and external price after the implementation of the reform will be:

- 1.00 for wheat;
- 1.35 for coarse grains,
- 1.06 for beef.

Since the final decision lead to price reductions that were lower than in the original proposals, we made the final levels of protection proportionally higher.

Regarding production and factor subsidies, we must take into account the interplay between the Agenda 2000 decisions and the 1992 reform. Accordingly, land subsidies for arable crops include both the payments

introduced with the MacSharry reform – corresponding to a 75% subsidy rate, as we have already seen –, and the increases introduced with the Agenda 2000 (+16.5%).³ In the case of livestock, we maintain direct payments as output subsidies, increasing them according to the Agenda 2000 decisions (+48%). The resulting trade protection and domestic support structure of commodities and endowments concerned are shown in Table 4.

Finally, we must take into account the changes introduced in the rate of compulsory set-aside. To change the set-aside rate from 14 percent in 1995 to 10 percent established with the Agenda 2000 package, we increase the productivity of and used in the arable crops sectors by 4 percent.

The effects of this reform in terms of output for the EU are summarized in Table 5. As it could have been expected, the abolishment of production subsidies has a significant impact on cereals and oilseeds. The output decrease, however, is much more drastic for oilseeds than for cereals, since the latter maintain some border protection. It can also be noticed, that the output subsidy increase is not enough to compensate for the protection reduction in the livestock sector. All animal sectors, though, are also hit by the changes in the arable crops, since the decrease in supply makes input more expensive.

Comparing Table 5 with Table 3, it is apparent that the impact of a complete liberalization would be much more drastic. This is reflected in the extent of the welfare gains in terms of allocative efficiency: 7554 million 1995 US\$ in the case of decoupling rather than 16150 million 1995 US\$.

³ In the case of oilseeds, payments are actually reduced in order to make them equal to those in the cereals sectors. However, since we assumed the same input subsidy rate, we can implement the same shock for all sectors concerned.

However, the total welfare impact of the (partially) “decoupled” scenario amounts to 5840 million 1995 US\$: that is, it is even larger than in the case of the “free trade” scenario. This somewhat surprising result depends on the terms of trade impact, which is much smaller (1974 million 1995 US\$, in absolute terms) in the latter experiment. In the case of decoupling, as a matter of fact, border protection is not abolished and this greatly reduces the terms of trade losses for the EU. As a consequence, benefits for the US are drastically reduced and for the rest of the world there is an overall welfare reduction.

The welfare impact of the decoupling scenario on the EU is consistently represented in terms of the uniform tariff index. The percentage rate of change of Δ^{hW} , as a matter of fact, is -9.8, showing a larger reduction than in the previous case.

5. Conclusions

In this paper we computed uniform tariff equivalents for the EU agriculture and food processing sectors using a global AGE model, namely the Global Trade Analysis project (GTAP) model and its associated data base. It is a global trade model that can be tailored according to specific needs by changing the aggregations of regions and sectors. In this case, a specific aggregation of regions and sectors was used in order to focus on agriculture and food processing in the EU. A number of modifications were made to the standard GTAP model in order to provide a more detailed representation of the CAP policy mechanisms and to introduce a new policy variable – the “uniform tariff equivalent”.

The main contribution of the paper is to extend and adapt the definition of the TRI, in order to make it consistent with the structure of a multi-regional AGE model. In this respect, we faced two major methodological issues.

Firstly, the TRI is originally defined under a small country assumption, and all existing (general equilibrium) applications are carried out with single region models assuming exogenous world prices. Obviously, such an assumption is quite unrealistic in the case of the EU agricultural sector, where the full welfare consequences of policy reform will depend upon the induced changes in imports and exports, and their consequences for the country's terms of trade. In order to use the TRI with the GTAP model, then, we needed to relax the small country assumption, defining a "TRI with endogenous prices" (Section 3.1).

Secondly, the TRI uses a Balance of trade function approach to the evaluation of welfare change (that is, a compensation measure), while the GTAP model, as well as most AGE models, evaluates welfare changes using the utility function embedded in the model (that is, a money metric of utility measure). In a distorted economy, the results of these two approaches do not coincide, so we needed to re-define the TRI according to the welfare metrics used in the GTAP model. This leads to the definition of a new index: the "hicksian TRI with endogenous prices" (Section 3.2).

These methodological issues have not only a theoretical interest, since our results show that the terms of trade impact can lead to rather counterintuitive results in terms of ranking alternative policy options (Section 4). Admittedly, the policy experiments that we have implemented

are not satisfactory under many respects, but that is not the point: rather, the point is that terms of trade have a profound impact on the restrictiveness index. The aim of the exercise was to extend the application of the new index to a broader family of models, namely multi-regional AGE models: this has proved possible. Thus, an interesting agenda for future research would be to extend the application of other “protection indexes” (such as the Mercantilistic TRI or the effective rate of protection) to global AGE models.

On the other hand, it must be acknowledged that the relaxation of the small country assumption raises several issues both in principle (e.g., problems of existence and uniqueness of the index) and in practice. As far as the latter are concerned, looking at the results presented here it could be argued that the Armington assumption leads indeed to excessive terms of trade effects. The question thus arises: how sensitive is the index to the specification of the model? In this respect, it should be clear that even a theoretically sound index cannot be better than the model it is used to measure it. There can be several strong prior reasons for doubting the validity of the functional and numerical structures of many AGE models in current use (O’Rourke, 1997; McKittrick, 1998). These are legitimate concerns and they can only be addressed by a more widespread use of sensitivity analysis.

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Table 1: Supply and export subsidies, and import tariffs (percent)

COMMODITIES	IMPORT(TAX)	EXPORT(TAX)	DOMESTIC(SUBS)
Oth. Commod.			
- wor	3.3	0.4	
- eur			-2.3
- usa	2.0	0.5	
Wheat			
- wor	12.4	-12.4	
- eur			58.0
- usa	12.4	-12.5	
Grains			
- wor	44.2	-44.2	
- eur			53.1
- usa	44.2	-44.1	
Vegetables			
- wor	5.6	1.00	
- eur			1.0
- usa	5.2	1.1	
Oil seeds			
- wor	0.0	0.0	
- eur			109.5
- usa	0.0	0.0	
Milk			
- wor	0.0	0.0	
- eur			8.9
- usa	0.0	0.0	
Crops			
- wor	12.5	-6.4	
- eur			1.3
- usa	15.4	-2.1	
Livestock			
- wor	19.0	-46.8	
- eur			13.3
- usa	31.1	-57.3	
Agribusiness			
- wor	25.5	-25.9	
- eur			-4.0
- usa	19.4	-8.7	
Nat. resources			
- wor	0.2	0.6	
- eur			0.4
- usa	0.3	0.4	

Table 2: Percentage shocks for complete EU agricultural policy liberalization

Commodities	Import(tax)	Export(tax)	Domestic(subs)
Wheat			
- wor	-11.04	-11.03	
- eur			-36.72
- usa	-11.05	-11.15	
Grains			
- wor	-30.65	-30.65	
- eur			-34.7
- usa	-30.65	-30.60	
Vegetables			
- wor	-5.30	0.97	
- eur			-1.03
- usa	-4.96	1.10	
Oil seeds			
- wor	0.00	0.00	
- eur			-52.27
- usa	0.00	0.00	
Milk			
- wor	0.00	0.00	
- eur			-8.18
- usa	0.00	0.00	
Crops			
- wor	-11.10	-6.03	
- eur			-1.27
- usa	-13.34	-2.08	
Livestock			
- wor	-15.94	-31.87	
- eur			-11.71
- usa	-23.70	-36.44	
Agribusiness			
- wor	-20.34	-20.59	
- eur			4.14
- usa	-16.24	-8.01	

Table 3: Changes in output in EU after the abolition of the CAP (in percent)

Commodities	Supply response
Oth. Commod.	0.7
Wheat	-33.0
Grains	-43.9
Vegetables	1.1
Oil seeds	-68.8
Milk	-10.7
Crops	-7.0
Livestock	-18.0
Agribusiness	-10.9
Nat. resources	2.4

Table 4: Supply subsidies, import tariffs, and export subsidies after CAP reforms (percent)

Commodities	Import(tax)	Export(tax)	Domestic(subs)
Wheat			
- wor	3.1	3.2	
- eur			0.0
- usa	3.1	3.0	
Grains			
- wor	37.3	37.3	
- eur			0.0
- usa	37.3	37.3	
Oil seeds			
- wor	0.0	0.0	
- eur			0.0
- usa	0.0	0.0	
Livestock			
- wor	10.3	-19.6	
- eur			19.68
- usa	14.3	-23.2	
Land			
- wheat			87
- grain			87
- cereals			
- oilseeds			87

Table 5: Changes in output in EU after the implementation of “Agenda 2000” (in percent)

Commodities	Supply response
Oth. Commod.	0.2
Wheat	-20.7
Grains	-19.4
Vegetables	-0.1
Oil seeds	-57.6
Milk	-1.1
Crops	0.1
Livestock	-4.9
Agribusiness	-0.8
Nat. resources	0.4